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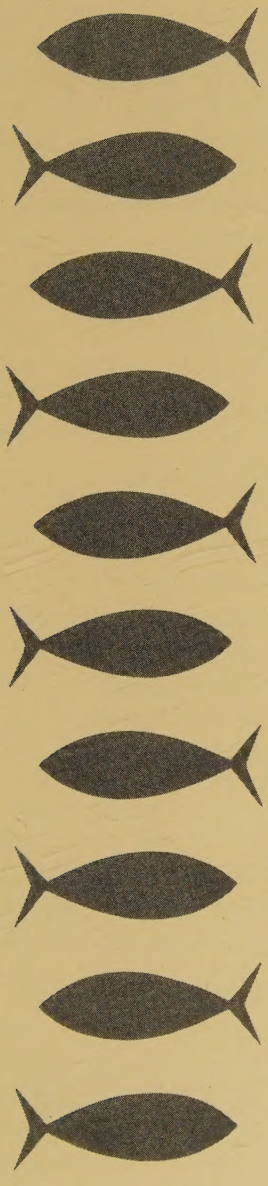

REPORT OF ACTIVITIES November-December 1992

ANTARCTIC ECOSYSTEM RESEARCH GROUP Page

1993 AMLR Field Season Begins 1

COASTAL FISHERIES RESOURCES DIVISION

Local Pacific Sardine Shows Impressive Recovery 1975-1991..... 1

MARINE MAMMAL DIVISION

Preliminary Dolphin-safe Project Completed 6

HONOLULU LABORATORY

Micronekton Advects over Southeast Hancock Seamount 10

PELAGIC FISHERIES RESOURCES DIVISION

Tuna Movement Model Developed..... 21

TIBURON LABORATORY

Hurricane Damage To Reefs Assessed 22

INFORMATION TECHNOLOGY SERVICES

Transition Plans Developed for the NMFS IT-95 Distributed Systems..... 25

PUBLICATIONS

List of 1992 Publications 26

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

1993 AMLR Field Season Begins

The NOAA Ship *Surveyor* departed from Seattle, Washington, on December 4 to begin a 1-month-long transit to Punta Arenas, Chile. *Surveyor* made the journey to the southern tip of South America as it has done for four consecutive seasons, to participate in research conducted by the Antarctic Marine Living Resources (AMLR) program, which was formed in support of U.S participation in the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic Treaty System. The program's field research is conducted in the waters surrounding Elephant Island, part of the South Shetland Islands group at the tip of the Antarctic Peninsula. Punta Arenas, a 3-day transit from the AMLR study area, is an ideal port for refueling, resupplying, and embarking of scientific personnel. As in past seasons, the AMLR studies will be conducted during the Antarctic austral summer, from mid-January to mid-March. The *Surveyor* will be in the study area for two 1-month legs with a 4-day port call between legs.

Antarctic krill, the predominant prey in the Antarctic pelagic ecosystem, feed multitudes of whales, seals, penguins, squid, and other life forms, including humans, who have made krill the target of a multi-nation commercial fishery. Because the goal of CCAMLR is to manage Antarctic living resources to maintain the integrity of the entire Antarctic ecosystem, and because krill are the keystone of that ecosystem, the AMLR program has designed its field research to describe the functional relationships between krill, their predators, and key environmental variables.

Two working hypotheses are incorporated in the AMLR research plan: (1) krill predators respond to changes in the availability of their food; and (2) distribution of krill is affected by both physical and biological aspects of their habitat. As part of the plan, a series of shipboard observations are made. They describe both within- and between-season variations in the distributions of nekton, zooplankton, phytoplankton, and water types. In addition, a seasonal field camp is occupied each year on Seal Island, a small island off the northwest coast of Elephant Island, where complementary studies on the reproductive success and feeding ecology of krill predators (predominantly Antarctic fur seals and chinstrap penguins) are conducted.

In past seasons, shipboard mapping of the waters surrounding Elephant Island have indicated that several water masses converge in the area, forming a hydrographic front along a shelf/slope break north of the island. High densities of phytoplankton and krill are strongly associated with the position of the frontal zone although seasonal timing of their appearance can vary by several weeks. The 1993 field program will continue to be a combination of descriptive surveys of the pelagic ecosystem in the vicinity of Elephant Island and more focused studies of selected processes. (J. Rosenberg, [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Local Pacific Sardine Shows Impressive Recovery 1975-1991

The Pacific sardine, *Sardinops sagax*, once supported the largest fishery in the western hemisphere. However, catches declined after World War II, and the fishery collapsed in the early 1960s. A complete moratorium was placed on the fishery beginning in the 1967-68 season. Although parts of the moratorium were deleted or changed after this season, it wasn't until 1986 that the moratorium was removed in its entirety. Theoretical population projections of sardine recovery following the moratorium by Murphy in 1967 and Lenarz in 1971 were set at about 20 percent per year.

In a paper just published (CalCOFI Rep. 1992 33:41) by La Jolla researchers Paul Smith, leader of Survey Systems Development and Evaluation; Nancy Lo, statistician; and John Butler, fishery biologist, based on data collected on California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises, sardine abundance for southern California is shown to have increased nearly 70 percent per year for the 17-year period from 1975 to 1991. This resembles the 50-percent-per-year rate of increase in egg abundance for the recently recovered Japanese sardine. The scientists state that even though

egg abundance cannot be used as a direct estimate of the spawning biomass of the sardine population which spawned them, the rise in abundance extending over 17 years would not be likely without either a mass immigration of fish from another habitat or a biomass increase in this habitat (Fig. 1; Fig. 2).

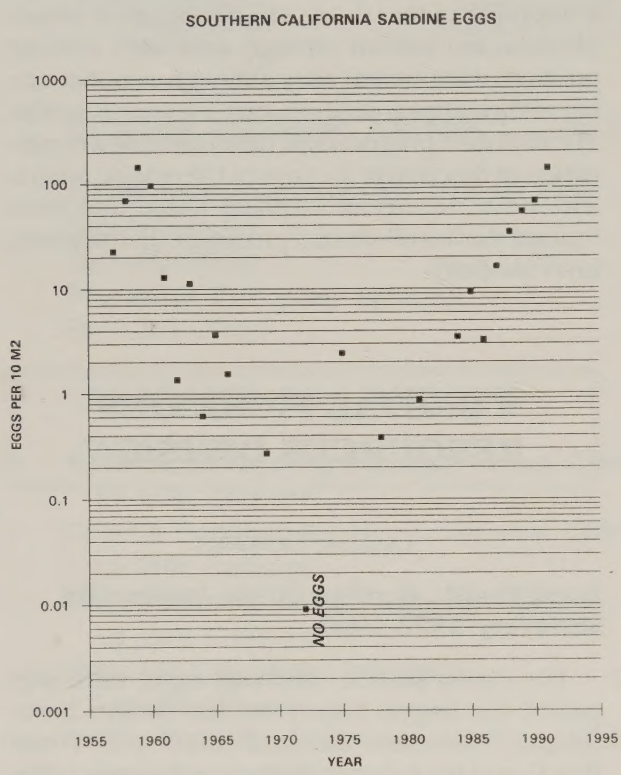

Figure 1. Semi-logarithmic plot of time series of sardine eggs per $10m^2$ in the southern California Bight, emphasizing rates and ratios. In 1972, no eggs were found. (A fishing moratorium was in place by 1973.)

The researchers developed a stage-specific matrix population model, showing survival, growth, and fecundity for each life stage of the sardine population. The model, taking into account the impact of a fishery moratorium, indicates a 20-percent population increase in sardines per year. Smith, Lo, and Butler state that the difference between the model's 20-percent increase and the southern California sardine population's actual 70-percent rate of increase indicates that another factor must be involved to achieve the much larger rates of population growth. For instance, a small sardine population inhabiting an area that earlier supported denser populations could be expected to mature earlier and have larger body sizes due to the increased food supply available to the smaller population. Maturing earlier and having larger body sizes are usually thought to lead to larger rates of population growth.

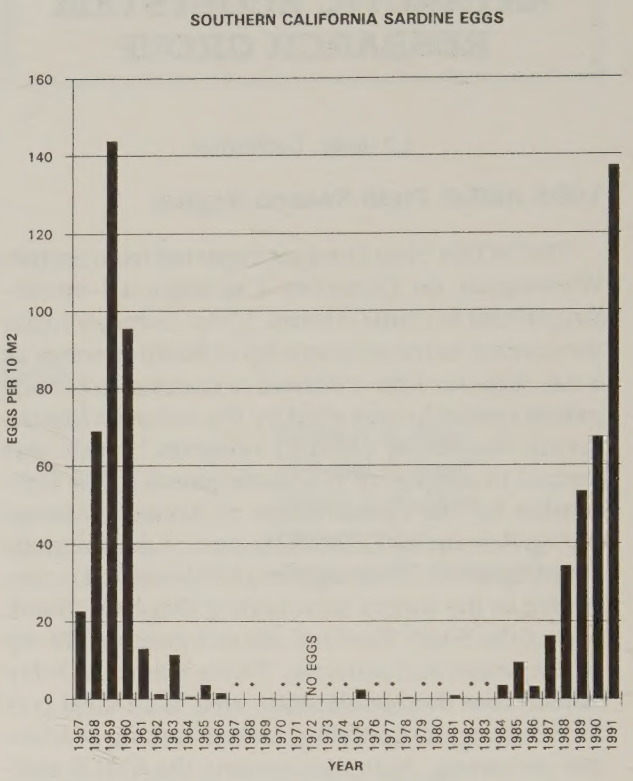

Figure 2. Arithmetic scale plot of sardine eggs in the southern California Bight, emphasizing quantities. * = no sampling effort.

In conclusion, Smith, Lo, and Butler state that, from the results of their research, it seems most likely that local sardine population growth has been supported by environmental changes in the rates of growth or survival of eggs, larvae, or juveniles as reinforced by the moratorium on fishing. (P. Smith, [619] 546-7169)

An Immunochemical Approach to Quantifying Predation by Euphausiids on the Early Stages of Anchovy

Theilacker and others, using a ELISPOT immunoassay to detect euphausiid predation on

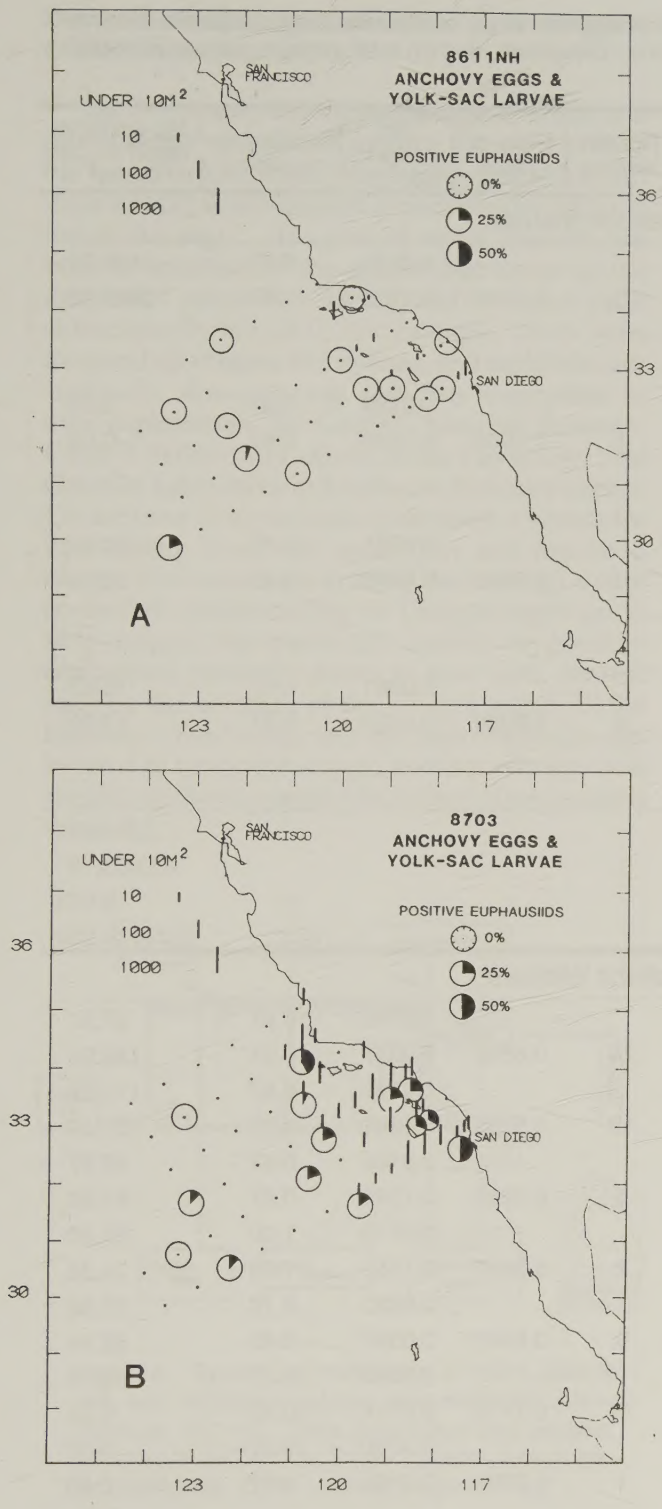

Figure 3. Distribution of positive euphausiid predators, expressed as percent positive, superimposed on northern anchovy egg and yolk-sac larval abundance for (a) November 1986 and (b) March 1987. Anchovy numbers adjusted to equal the average abundance under 10 m^2 of sea surface.

larval anchovy, developed antibodies to the yolk protein of the northern anchovy, *Engraulis mordax*, and in a laboratory study, used the immunoassay to detect the yolk protein in the stomach contents of a euphausiid crustacean *Euphausia pacifica*.

In a recent study, scientists at Southwest Fisheries Science Center applied the ELISPOT immunoassay to detect predation by euphausiids on anchovy in the field. They collected anchovy eggs and larvae and euphausiids during two California Cooperative Oceanic Fisheries Investigations surveys: one in November 1986, prior to peak spawning of northern anchovy, and one in March 1987, during peak anchovy spawning. They determined the incidence of predation for both survey cruises (Fig. 3). The November collection was considered to be a control.

The scientists estimated euphausiid abundance for six species, the daily mortality rate of anchovy eggs and yolk-sac larvae, and the daily mortality rate of anchovy due to predation. Rates of predation were determined from euphausiid feeding rates and digestion rates. Estimates of digestion (the detection time of yolk protein in a predator's gut) were essential for estimating the daily predation mortality rate.

For comparison purposes, the scientists divided stations into two categories. Category 1 included stations with a high euphausiid predation incidence as determined by the immunoassay (mainly nearshore stations), and the other category included stations with a low predation incidence (mainly offshore stations) (Table 1). Between 50-80 percent of the natural mortality of northern anchovy eggs and yolk-sac larvae can be explained by euphausiid predation. Euphausiids ate 2.8 percent of the anchovy population per day in the nearshore area and 1.7 percent in the offshore area.

The study showed that euphausiids are important predators on the early life-history stages of anchovy. The impact of the euphausiid population was substantial. Euphausiid crustaceans are ubiquitous in the sea and numerically one of the major plankton organisms in the eastern North Pacific having a great potential to impact all fish populations that spawn pelagic eggs. The manuscript is to appear in Marine Ecology Progress Series. (G. Theilacker, [206] 526-4149; and N. C. H. Lo, [619] 546-7123)

Table 1. Comparison between the high- and low-predation stations of (a) euphausiid species-specific feeding rates, (b) the impact of euphausiid predation on the anchovy population, and (c) total anchovy natural mortality rates. d^{-1} = per day; h^{-1} = per hour.

Predator		Ind. per 10 m^2	No. analyzed	No. not feeding	Freq. of zeros	[1]No. eaten ind.$^{-1}$ h^{-1}	Fraction co-occurring	No. anchovy eaten d^{-1} per 10 m^2
High predation stations 'inshore'								
Euphausia pacifica	6-11 mm	1269				0.0125	0.87	138.05
	>11 mm	1804	114	72	0.6316	0.1313	0.87	2060.65
E. recurva	6-11 mm	62						
	>11 mm	0	0					
E. gibboides	6-11 mm	32				0.0189	0.87	5.25
	11.5-15	0	2	1	0.5000	0.1980	0.87	0.00
E. eximia	6-11 mm	11						
	>11 mm	0	0					
Nematoscelis difficilis	6-11 mm	816				0.0061	0.70	34.68
	>11 mm	138	5	4	0.8000	0.0638	0.40	35.19
Nyctiphanes simplex	6-11 mm	508						
	>11 mm	11	0					
Other	6-11 mm	202				0.0061	0.87	10.67
	>11 mm	22	5	4	0.8000	0.0638	0.87	12.20
Total	6-11 mm	2900						
	>11 mm	1975	126					
Total no. of anchovy eaten								2291.45
No. of anchovy eggs and larvae per 10 m^2								81,633.18
Fraction of anchovy population eaten d^{-1}								0.028
Total mortality *Z* (SE)								0.036 (0.036)
Low predation stations 'offshore'								
E. pacifica	6-11 mm	3130				0.0032	0.87	87.27
	>11 mm	512	27	24	0.8889	0.0337	0.87	149.90
E. recurva	6-11 mm	723				0.0178	0.87	111.93
	>11 mm	93	25	13	0.5200	0.1868	0.87	151.17
E. gibboides	6-11 mm	113				0.0128	0.87	12.57
	11.5-15	53	8	5	0.6250	0.1343	0.87	61.92
E. eximia	6-11 mm	252				0.0110	1.00	27.80
	>11 mm	21	3	2	0.6667	0.1158	1.00	24.33
Nematoscelis difficilis	6-11 mm	1675				0.0032	0.70	37.58
	>11 mm	396	9	8	0.8889	0.0337	0.40	53.31
Nyctiphanes simplex	6-11 mm	836				0.0068	0.87	49.74
	>11 mm	10	18	14	0.7778	0.0718	0.87	6.25
Other	6-11 mm	1814				0.0000	0.87	0.00
	>11 mm	41	1	1	1.0000	0.0000	0.87	0.00
Total	6-11 mm	8543						
	>11 mm	1126	91					
Total no. of anchovy eaten								717.78
No. of anchovy eggs and larvae per 10 m^2								41,920.53
Fraction of anchovy population eaten d^{-1}								0.017
Total mortality *Z* (SE)								0.036 (0.036)

Dover Sole Energetics under Low Oxygen Conditions Studied

The Dover sole, *Microstomus pacificus*, is one of a group of fish species that migrate throughout their life from shallow water into the Oxygen Minimum Zone (OMZ) where oxygen concentrations fall to as low as 0.3 mg/L. The goal of recent research has been to determine if the species that comprise the deepwater groundfish fishery, and have their peak abundance in the OMZ (for example, Dover sole, long and shortspine thornyhead, and sablefish), are unusually slow-growing and thus susceptible to over-exploitation. Ed Goolish, National Research Council Fellow, and others in the Physiology and Genetics Laboratory at Southwest Fisheries Science Center have designed and constructed a system for maintaining these fish under low and regulated oxygen concentrations to study their biology under controlled conditions (Fig. 4). Using nitrogen gas to strip oxygen, this system can regulate oxygen concentrations precisely down to near zero, limited only by the accuracy of the oxygen meter. If the biomass of fish is large enough, their respiration can be used to lower the oxygen without nitrogen and regulation then occurs by the inflow of oxygenated water.

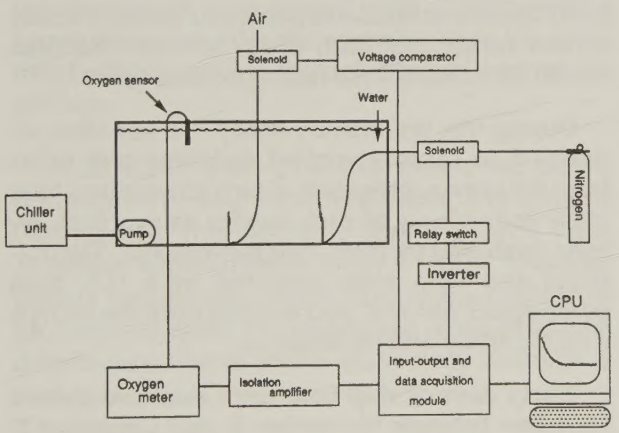

Figure 4. System for maintaining a 1500-L tank at low and regulated oxygen concentrations (temperature, 5-7 °C). Data acquisition and analysis software is DATACAN; Sable Systems, Los Angeles, California. CPU = central processor unit.

Twenty-five Dover sole were acclimated to 0.5 mg/L oxygen for 8 weeks and sampled for metabolic and respiratory variables that have also been collected from fish at sea. These included red blood cell concentration (hematocrit), blood oxygen affinity (P50), muscle water and enzyme activity, relative heart size, and relative gill size. Feeding and growth rates were also monitored and compared to control fish at 7.0 mg/L. The most notable response of the fish to low oxygen was a dramatic depression in food intake (cut squid). Over the course of the 2-month period, Dover sole maintained at 0.5 mg/L consumed only 52 percent of the ration of control fish (Fig. 5). Data from this and other experiments indicate, however, that the growth of fish at low oxygen is similar to, or in some cases greater than, fish at high oxygen concentrations. No significant change in the water content of the muscle was seen, but decreases in relative heart size (20 percent) and muscle enzyme activity (citrate synthase) suggest that the increase in food conversion efficiency was the result of a decrease in the rate of energy used for maintenance. These changes in heart size and enzyme activity are similar to those previously reported for large Dover sole occurring in the OMZ.

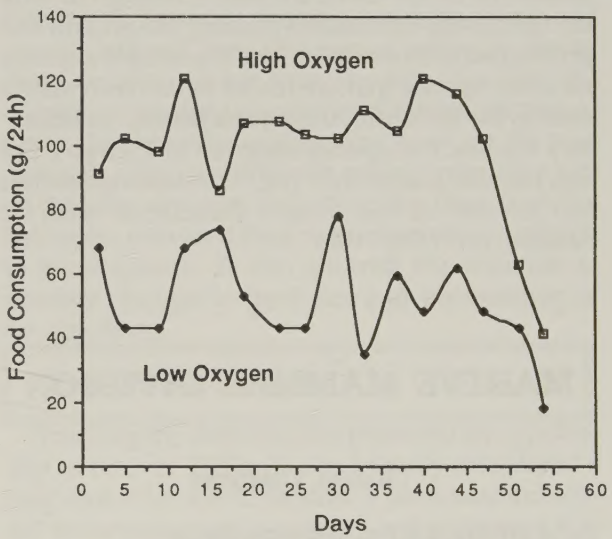

Figure 5. Rate of daily food consumption by Dover sole maintained either at high (7.0 mg/L) or low (0.5 mg/L) oxygen concentration; biomass is nearly the same in each treatment. Decreased rates of feeding during the last week are the result of Dover sole reaction to disturbances caused by sampling.

The lower limit of oxygen concentration for Dover sole survival was also determined for fish acclimated to either high or low oxygen for an 8-week period. The fish were combined into one tank and the oxygen concentration was decreased from 1.0 to 0.0 mg/L over approximately a 4-day period. Dover sole acclimated to high oxygen died first at an average oxygen concentration of 0.23 mg/L. Fish acclimated to low oxygen survived down to an average oxygen concentration of 0.08

mg/L, with the last individual tolerating 0.06 mg/L for one day. A multiple regression analysis, to explain the order of death at low oxygen concentrations, was done with the following predictors for each individual: hematocrit, P50, heart size, gill size, muscle enzyme activity and percent water, body size, and growth rate. A preliminary analysis indicates that traits involved in blood-oxygen carrying capacity (for instance, hematocrit and P50) are more important to survival than traits indicative of decreased metabolism and energy demand (for example, relative heart size, growth rate, muscle enzyme activity, and water content). This conclusion is also suggested by the observation that, among the fish acclimated to low oxygen, fed fish with presumably higher metabolism survived significantly longer than starved fish; a result contrary to original predictions.

From these studies, it appears that the hypoxic conditions of the OMZ are severe enough to limit the food consumption and possibly the growth and production of Dover sole. This is probably also true for other species that are found in this community such as the sablefish, *Anoplopoma fimbria*. In laboratory studies, this species survived at 1.0 mg/L but was not able to live at 0.5 mg/L, indicating that it is less tolerant of low oxygen than Dover sole. (E. Goolish, [619] 546-7108)

MARINE MAMMAL DIVISION

La Jolla, California

DOLPHIN-SAFE RESEARCH PROGRAM

Preliminary Dolphin-safe Project Completed

On December 5, 1992, the Dolphin-safe Research Project in the eastern tropical Pacific Ocean was completed. Using dolphin-safe research funds allocated by the U.S. Congress and ship charter funds from NOAA, the NOAA research vessel *McArthur* and the commercial tuna purse-seiner *Nicole K.* embarked upon a combined research effort directed toward developing a better understanding of the tuna-dolphin associations characteristic of this area. The primary goal of the research program was to collect information that will aid in developing methods of catching large yellowfin tuna in the eastern tropical Pacific Ocean without endangering the dolphins that often occur in association with these fish.

The following summary was provided by Michael Scott of the Inter-American Tropical Tuna Commission (IATTC). Scott was the scientific director and chief scientist for the recent cooperative research cruise fielded by the Southwest Fisheries Science Center (SWFSC) and IATTC, as part of the SWFSC's Dolphin-safe Research Program (E. Edwards, [619] 546-7099)

Tracking Study of Dolphins and Tuna

The nature of the tuna-dolphin bond is still unclear despite the many years of research devoted to both tunas and dolphins in the eastern tropical Pacific Ocean. The IATTC, in cooperation with the NMFS' Southwest Fisheries Science Center and the University of Hawaii, conducted field research to study the tuna-dolphin relationship by simultaneously radio-tracking spotted dolphins and sonic-tracking yellowfin tuna from the same aggregation. The value of this information is twofold. Scientifically, the study of tuna and dolphin movements and interaction, in conjunction with food-habit studies conducted by the IATTC and NMFS, will help to establish the longevity and dynamics of the tuna-dolphin bond and the degree that it is food-based. Tactically, scientists can determine whether the bond loosens or breaks at particular times or under certain conditions, and, if so, whether the tuna would be vulnerable to fishing at such times.

During this preliminary study, the scientists attempted to capture spotted dolphins and tunas from the same aggregation, attach transmitters to as many individuals of each species as practical, release them, and monitor their movements. The dolphins and tuna were captured by a U.S. tuna purse-seiner *Nicole K.* and tracked from the NOAA ship *McArthur* and its launches.

Thirty days of ship time were available aboard *McArthur* between November 6 and December 5, 1992. Two areas were targeted where the seas were likely to be the calmest during November: the area within 250 miles of the coast of Costa Rica and Panama, and the area between 90-100° W and 10-12° N. *Nicole K.* was chartered by the NMFS for the same 30-day period to capture tuna and dolphins.

The scientists attempted to capture the tuna prior to the backdown procedure by angling from a 5-m boat inside the net, using handlines. Large fish were to be drawn near the boat, measured, and lanced in the dorsal musculature with a sonic transmitter attached to a flat dart head. After tagging and measuring, the leader from the handline would

be cut and the fish allowed to swim free inside the net until the entire tuna-dolphin aggregation was released as simultaneously as possible. When capturing the tuna by handlining did not succeed, skin-divers applied the transmitters with a lance to free-swimming fish just prior to and during backdown. Ultrasonic transmitters, having a nominal longevity of 3 days with an operating range of 0.5-0.75 mile, were used. Two types of transmitters were used: one type provided location information while the other transmitted the ambient pressure to monitor the animal's swimming depth in addition to location.

The dolphins were caught by swimmers prior to backdown and placed in a raft. The dolphins were outfitted with radio transmitters mounted on plastic saddles that were attached to the dorsal fin with two delrin pins. The delrin pins were secured by magnesium nuts that corrode in sea water, releasing the package in days or a few weeks. The length and sex of the dolphins were recorded, and they were released inside the net so that the entire aggregation could be released together. Time-depth recorders (TDRs) were also attached to some of the dolphin transmitter packages. This device recorded the depth of the package every 10 seconds, which could then be compared with the vertical movements of tuna tagged with depth-sensitive transmitters. In order to recover the data, the scientists had to recapture the dolphin and remove the package.

A SEACAT mini-CTD (for measuring depth, temperature, and salinity) or an expendable bathymetric thermometer was deployed from *McArthur* approximately every 4 hours. Observations of bird flocking behavior were also made from *McArthur* to study the association of seabirds with dolphins and tunas and to study daily variation in flock size.

Tagging Effort

Eleven sets were made on spotted dolphins. Dolphins were tagged during five sets, and tuna were tagged during two of those five sets. Of the 30 days of ship time available, 7 days were lost due to transit time, and 9 days due to weather or seas that did not allow *McArthur*'s tracking boats to be launched. An additional 5 days were spent searching in areas where the density of spotted dolphins was low because the scientists had to leave areas of higher density due to poor weather. Only 9 days were spent in higher-density areas with good weather.

Tracking Results

Six dolphins were successfully tracked during the study; five were tracked for 1-2 days; a sixth track was abandoned after 2½ hours to attempt another set. None of the five tagged tuna was tracked, generally due to difficulties in releasing the tuna from the net. The dolphin radio-tracking system worked very well, with ranges up to 13 miles from *McArthur* and *Nicole K.* and greater than 5 miles from the launches. The dolphins did not appear to react to close approach by the tracking launches, nor did they avoid *McArthur* when tracking from less than 2 miles.

Tracking the dolphins, even without the simultaneous tracking of the tuna, proved to be worthwhile for several reasons. It provided data on the movements and diving times of six spotted dolphins. Their movements, speeds, and surfacing patterns can be compared under different circumstances: for instance, feeding versus traveling, and overall "normal" behavior versus behavior during chase or after release from the net. Tracking the dolphins overnight also reduced the search time to find a dolphin-tuna aggregation to set on the next morning. This capability for making repetitive sets on the same dolphins and observing them from the helicopter provided data on the recruitment of tuna to the dolphins. It also allowed the scientists to monitor changes in herd size and composition of the dolphins.

Time Depth Recorders

Tracking the dolphins also provided an opportunity to recover TDRs. It was initially considered a long shot to be able to monitor a particular individual while setting on a running and scattering dolphin herd, then capture the portion of the herd containing that individual, grab that individual out of the herd while in the net, and recover the tag. Nonetheless, the scientists recovered two of the three TDRs deployed on dolphins after they had been at liberty for 25-44½ hours.

The TDRs measured and stored the depth of the dolphins every 10 seconds and the ambient temperature every minute. Thus, a history of the dolphin's diving behavior was preserved when the TDR was recovered. This is the first dive-depth data ever collected for spotted dolphins. The diving data can be interpreted to determine the times and depths that dolphins feed and their preferred swimming depths, particularly in relation to the thermocline. It can also be potentially useful for calibrating herd size and abundance estimates by calculating

the percentage of time that, on average, a dolphin would be visible at or near the surface.

Future Research

During this study, the scientists have resolved several of the uncertainties that were inherent in such an ambitious project. They discovered that they could capture, tag, and track dolphins effectively. The tracking launches could closely approach the dolphins without disrupting their behavior. The fact that the scientists could recapture individual dolphins to recover TDRs was particularly heartening. They found that the tuna could be tagged by swimmers in the backdown channel. They found that if sufficient numbers of tuna were present, they could be backed out of the net with the dolphins.

During future studies, the scientists will refine their methods for tagging the tuna and releasing them from the net nearly simultaneously with the dolphins, thus allowing them to successfully track both species. They found that at least 10-15 tons of tuna should be in the net to successfully tag and release tuna. Larger schools came closer to the surface, particularly as the net constricted, making it easier to tag the tuna. Larger schools were also easier to back out of the net. (M. Scott, IATTC, [619] 546-7045)

POPULATION IDENTITY PROGRAM

Genetics Program Passes Two-year Mark

The Genetics Program of the Southwest Fisheries Science Center's (SWFSC) Marine Mammal Division has only been in existence for a little more than two years. The program's impetus was a meeting sponsored by the International Whaling Commission (IWC) held from September 27 to 29, 1989, at the SWFSC, under the chairmanship of John Harwood of the Sea Mammal Research Unit at Cambridge, England, and coordinated by a working group consisting of Harwood; Andrew Dizon, leader of the Biology Assessment Program at SWFSC; Greg Donovan, IWC; and Rus Hoelzel of the University of Cambridge. At that meeting, the importance of the concept of managing local self-sustaining populations as opposed to the typologically defined species based on physical type was reiterated and it was agreed that the best current tool was sequence analysis of the rapidly evolving, maternally inherited mtDNA molecule. This approach is accomplished by comparing the DNA sequence of individual animals and is grounded in the fundamental assertion that at some degree of resolution (number of individual samples examined and the fraction of the nuclear and mitochondrial DNA examined), all organisms are genetically distinct from each other.

The Program's genesis corresponded with the development by Rus Vetter, physiologist, and John Hunter, chief of the Coastal Fisheries Resources Division, of a molecular genetic laboratory devoted to fish stock and systematic problems. They generously allowed their laboratory space to be invaded and their equipment at least partially co-opted for use on mammals. Through a generous contribution in FY 92 by NMFS' Office of Protected Resources (F/PR), the Mammal Genetics program has been able to make improvements to the laboratory and to fill some of the equipment needs. The introgression of mammal genetic research methods into fish genetic research methods has proved fruitful and approaches have evolved so that both groups are using common techniques, which have led to minimized costs and maximized efficiency.

Briefly, the mammalian sequencing procedure involves extracting all the DNA (both nuclear and mitochondrial) from salt-preserved skin samples. The specific region of the DNA to be analyzed is "amplified" with the polymerase chain reaction (PCR) procedure. The PCR is a simple technique for copying specific regions of DNA. The number of copies of the DNA fragment increases exponentially so that more than 100 billion copies can be made in a few hours--hence the term, "amplified." The use of the PCR process allows focusing on a highly specific portion of the DNA. The SWFSC uses two regions of the mitochondrial DNA molecule: the fast-evolving D-loop region for intra-specific studies and the less rapidly evolving cytochrome *b* gene, for higher level systematic studies. The cytochrome *b* gene transports electrons to the molecular oxygen. After amplification, the sequence is determined by standard sequencing methods.

The sequence information is used to build phylogenies (historical common ancestry relations) using established computer-based methods; however, what is new in the Genetics Program's approach is to use this phylogenetic information to calculate gene flow or average dispersal distances (how far an animal disperses from its birth location). By doing so, the scientists hope to provide a quantitative measure of "stockness" that can be incorporated into existing analytical population abundance methodology.

In the two years since the Marine Mammal Genetics Program has been in existence, a fully-equipped, modern molecular biology facility has

been set up to receive, archive, extract, amplify, and sequence marine mammal tissue samples. Prior to the development of a dedicated laboratory, work on some projects was carried out at the University of California, Scripps Institution of Oceanography. Those projects were completed in the latter part of FY 92, using F/PR funds.

The following covers genetic research thus far carried out by the Genetics Program of the SWFSC's Marine Mammal Division.

Common Dolphin, *Delphinus delphis*

This work, initiated June 1991 and completed in FY 92, used analysis of mtDNA control region and cytochrome *b* sequences to delineate two sympatric forms of common dolphin that are killed in California and eastern tropical Pacific fisheries. Sympatric forms of the common dolphin occupy the same range without loss of identity from interbreeding; however, these two forms are managed currently as a single unit. The degree of genetic uniqueness of the two sympatric forms demonstrates long-term reproductive isolation. Additional specimens from the Black Sea were analyzed and demonstrated to be genetically distinct from the eastern Pacific forms. Interestingly enough, the Black Sea form was genetically more closely related to one of the eastern Pacific forms than the two eastern Pacific forms were related to each other. A manuscript reporting the work has been authored by Patricia Rosel, Scripps Institution of Oceanography graduate student; Dizon; and John Heyning, of the Los Angeles Museum of Natural History. It has been submitted and is undergoing review.

Harbor Porpoise, *Phocoena phocoena*

By early 1991, sequencing of control region and cytochrome *b* gene mtDNA was initiated and currently over 115 samples of the 6 species representing the family Phocoenidae have been sequenced, on 88 harbor porpoises alone. Phylogenies produced by the two gene regions establish *Neophocaena phocaenoides* as the most basal member of the family, confirm a close relationship between *Phocoena spinipinnis* and *P. sinus*, and suggest the association of those two with *Australophocaena dioptrica*. The last association contradicts a recent reclassification of *A. dioptrica* (Barnes 1985), which was originally described as a member of the genus *Phocoena*. The molecular data as well as some recent morphological work in progress by William Perrin, senior scientist at SWFSC, supports returning *A. dioptrica* to *Phocoena*. A manuscript reporting the molecular systematics work, authored by Rosel; Margo Haygood of Scripps Institution of Oceanography; and Perrin, will be submitted.

Stock structure of harbor porpoises off the east and west coast is to a large degree uncertain at this time, and all putative stocks (those assumed to exist), except the California stock, are rated as alpha stocks (those stocks that are of high management concern). Therefore, there is a high priority to increase our understanding of harbor porpoise stock structure, and the Genetics Program scientists have concentrated much of their effort in characterizing the amount and distribution of genetic variation existing among harbor porpoise populations in the northeast (NE) Pacific and North Atlantic using, as in the case of common dolphin, Black Sea harbor porpoises as a reference. Again, the control region of mtDNA from the three populations of harbor porpoise was amplified and sequenced. No sequences were found to be shared among the three ocean basins. Divergence was high, averaging from 2.2 percent between the North Atlantic and Black Sea and 5.5 percent between the NE Pacific and North Atlantic. Within the NE Pacific, two separate groupings of sequences were found, but there was no obvious concordance with geographic distribution. The results suggest that (1) two previously distinct groups are now (or have recently been) freely intermixed, (2) sufficient gene flow, although possibly minimal by fishery management standards, exists along the coast of North America preventing the development of local, genetically-distinct populations, or (3) there are two distinct breeding stocks that mix during some time in their life cycles. Funds are requested to enlarge the data set, which will make possible quantitative estimates of gene flow and dispersal distance. A manuscript, authored by Rosel and Haygood, reporting the harbor porpoise stock structure, has been submitted and is undergoing review.

Northern Right Whale Dolphin, *Lissodelphis borealis*

To date, Genetics Program scientists have sequenced a portion of the control region from the mtDNA of 51 individuals collected from the high seas, large-scale drift-net fishery, from biopsied material collected from bow-riding animals during coastal surveys off California, and from beach-cast salvage. This alpha-stock species is most frequently killed in the high-seas drift nets. The gillnet sample spans about 120° W longitude to 160° E longitude; the one from the local California strandings and fisheries extends from about 30° N to 40° N latitude.

Initial gene flow calculations (initial because data set isn't totally complete yet) indicate that the popu-

lation is in equilibrium because recently arisen matrilineal lineages are as completely dispersed as older lineages. Also, distribution of individual lineages indicates a fairly high level of exchange although there are distinctions between the populations based on genetic-difference calculations between and within populations. It will be interesting to find out whether the new sequences being collected will strengthen or weaken the differences in genetic differences currently observed.

RAPD Analysis

Using beluga, *Delphinapterus leucas*, tissues, Genetics Program scientists have begun to test the feasibility of a new technique designed to quickly assess overall genetic differences between the nuclear genomes of individuals. The technique involves the amplification of DNA using the PCR technique similarly to what is done prior to sequencing a specific region. Rather than causing the amplification of a specific region for later sequencing, the randomly amplified polymorphic DNA (RAPD) relies on producing multiple DNA segments. Comparisons of segment patterns from various individuals provides a way of rapidly examining overall genetic differences. They have been used, among other things, as markers for strains and disease resistance. If the technique proves as effective for mammals as it has for the other plants and prokaryots, it will be a very powerful stock identity tool. (A. Dizon, [619] 546-7089)

HONOLULU LABORATORY

Honolulu, Hawaii

FISHERIES OCEANOGRAPHY RESEARCH PROGRAM

Micronekton Advects Over Southeast Hancock Seamount

As an adjunct to fisheries research on armorhead at central North Pacific seamounts, a variety of ecological studies were carried out. In one of these studies, Oceanographer Christopher Wilson conducted dissertation research on micronekton populations that led to the completion of his Ph.D. degree in Oceanography at the University of Hawaii's (UH) School of Ocean and Earth Science and Technology under the guidance of Fishery Biologist (and UH faculty member) George Boehlert and UH Oceanographer Eric Firing. The collaborative work was conducted under the auspices of the Joint Institute for Marine and Atmospheric Research.

Wilson's results were based upon biological data from hydroacoustic and net samples and information on current patterns from a vessel-mounted acoustic Doppler current profiler (ADCP), collected during four research cruises at Southeast Hancock Seamount in 1987 and 1988. The seamount, located on the northern Hawaiian Ridge, has a circular, flat-topped summit of about 4.5 km^2 at a depth of 260 m. Over small time and space scales, currents affected the distributional patterns of the two dominant seamount-associated micronekton--the sternopthychid fish, *Maurolicus muelleri*, and the lophogastrid mysid, *Gnathophausia longispina*.

Current patterns over the summit varied within and among cruises. On the first and second cruises, currents were predominantly to the east at average speeds of 23 cm s^{-1} and south at 17 cm s^{-1}, respectively. On the third and fourth cruises, mean currents were weaker (≤5 cm s^{-1}) and much of the current field could be described as rotary motions at tidal frequencies.

The distribution of *G. longispina* and *M. muelleri* over the summit was a result of behavioral and physical processes. Both species were present above the summit during each cruise and vertically migrated into the water column nightly. Currents over the summit had the potential to advect animals an average of about 6 km per night on the first two cruises and about 2 km per night on the last two cruises. Biological results indicated that *G. longispina* and *M. muelleri* were advected and/or moved to the downstream side of the summit by the end of the night. As an example, current patterns to the south during the winter 1988 cruise (Fig. 1)

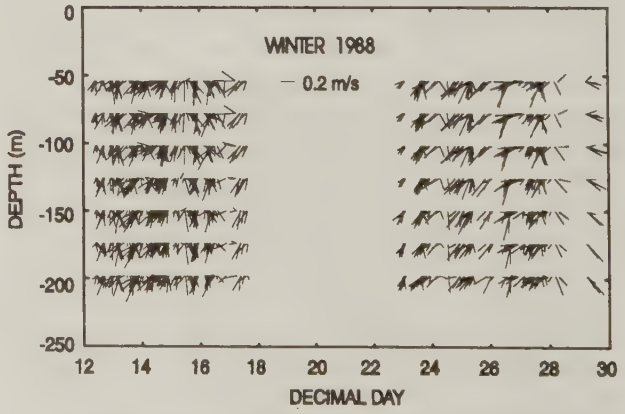

Figure 1. Feather plot of current velocity estimates in each depth stratum at Southeast Hancock Seamount for winter 1988.

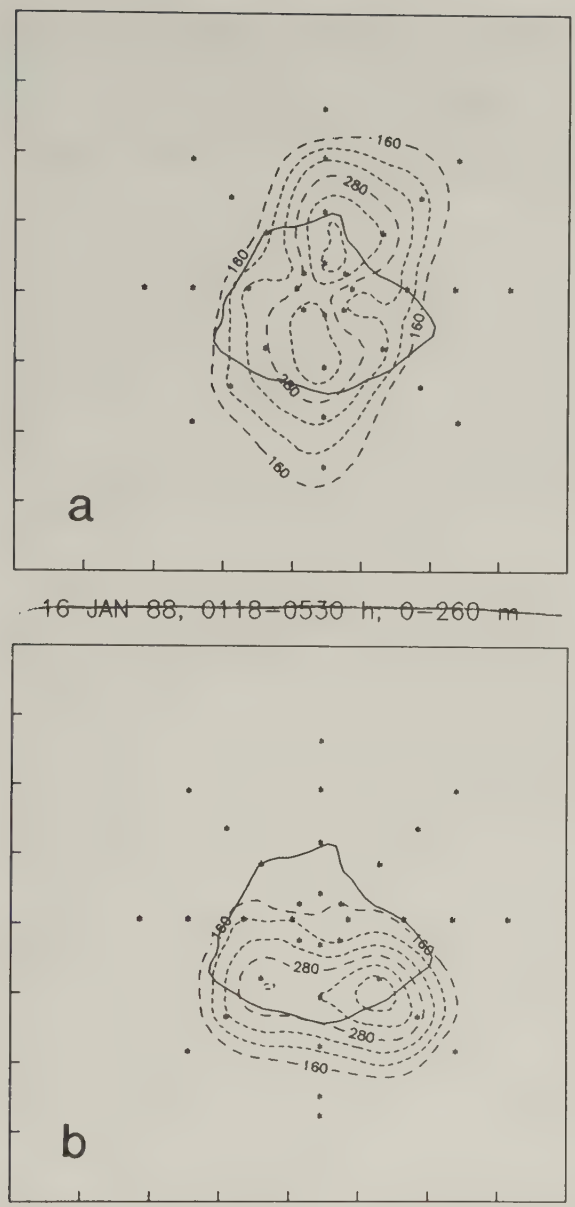

Figure 2. Contoured relative acoustic abundance of the sound-scattering layer, in which *G. longispina* and *M. muelleri* were found to be the main component, above Southeast Hancock Seamount summit from the first (a) and last (b) part of a representative night for the winter 1988 cruise. Asterisks are midpoints of areas along transects where abundances were estimated and used as data points for contouring. The solid lines are the 300 m bottom contour. Tick marks on plot axes are 0.01° latitude or longitude (about 1 km).

resulted in a southerly displacement of the acoustically measured micronekton abundance (Fig. 2). *G. longispina* and *M. muelleri* were the dominant species found in this acoustically measured abundance.

Distributional and population data from both acoustic and net sampling suggested that *G. longispina* and *M. muelleri* resisted advection from the area to maintain their populations at the seamount. Regardless of current patterns, few specimens were taken beyond 5 km of the summit. Reproductive information and analysis of population size classes for *G. longispina* argue against recruitment from other areas. Coherent movements of these dominant acoustic scatterers were detected above the summit at sunrise and may play an important role in the population maintenance of these seamount-associated species. (C. Wilson, [206] 526-4329; G. Boehlert, [808] 943-1211)

INSULAR RESOURCES INVESTIGATION

Workshop Held on Decadal-scale Physical and Biological Variation in the Central Pacific

A 2-day workshop on variation in the marine environment and ecosystem in the Northwestern Hawaiian Islands, co-hosted by the National Marine Fisheries Service (NMFS), Honolulu Laboratory and the University of Hawaii's Joint Institute for Marine and Atmospheric Research, was held in Honolulu, December 3-4, 1992 (Fig. 3). It was well attended by a wide variety of Hawaii scientists as well as five invited experts. The physical oceanography data presented by a number of oceanographers indicated that a significant change in the

Figure 3. Hosts and invited specialists of the Workshop on Variation in the Marine Environment and Ecosystem around the Hawaiian Archipelago, held at the East-West Center at the University of Hawaii. L-R: Jeffrey Polovina (co-host), Warren Wooster, Gary Mitchum (co-host), Jim Schumacher, Dan Ware, Nick Graham, and Mark Luther.

physical environment occurred in the North Pacific, specifically around the Hawaiian Archipelago, between the mid-1970s to the early 1990s. This change could be described as an event that began in the mid-1970s, reached maximum strength in the early 1980s, and returned to normal levels by the early 1990s. This change was characterized by stronger winds and a deepening of the mixed layer and the 15-degree isotherm. It was also suggested that the entire subtropical gyre shifted southward during this period. Biological data collected since the 1980s on sea birds, monk seals, lobsters, and reef fishes were presented and showed declines in productivity of 30-50 percent at some islands in the Northwestern Hawaiian Islands from the early 1980s to the present. Hypotheses linking the changes in physical and biological systems were presented and discussed. All the data are consistent with the hypothesis that this physical change resulted in higher biological productivity that reached a maximum in the early 1980s and has now declined back to lower long-term levels. Recently observed declines in productivity at higher trophic levels may represent a response to the return to lower long-term primary productivity. (J. Polovina, [808] 943-1218)

Analyses Completed for Reef Fishes at French Frigate Shoals

Statistical analyses evaluating possible temporal changes in reef fish densities at French Frigate Shoals (FFS) in the Northwest Hawaiian Islands (NWHI) were recently completed. Analyses compared the densities of shallow-water (<10 fm) reef fishes, estimated by Insular Ecology Program diver-biologists in summer 1992, with fish densities estimated at the same stations a decade earlier by personnel of the University of Hawaii (Manoa), Zoology Department, Hawaii Cooperative Fishery Research Unit, led by Dr. James D. Parrish. These two series of data were sampled and analyzed according to a matched-pairs ("before-after") design at a total of nine stations, located on the barrier reef and on patch reefs in the lagoon near Tern Island. "Before" (baseline) data were collected at the nine stations during fall 1980 and spring 1983; analogous "after" data were collected in summer 1992. The July-August 1992 Report of Activities provides additional specifics on sampling design.

The summer 1992 field work, and the comparisons with prior data described herein, were prompted by Marine Mammal Research Program observations of recent, marked increases in the mortality of juvenile, particularly weanling, monk seals, *Monachus schauinslandi*, at FFS. There is a continuing likelihood that the observed decreased survivorship of seals at FFS is due to starvation and therefore might be related to declines in the abundance of monk seal prey.

Lack of data on the specific diet and foraging microhabitats of monk seals, however, precluded a priori targeting of fish species for analyses. Species-level comparisons also generally lacked adequate statistical power. The evaluation therefore focused on total reef fishes and the two fundamental trophic levels (herbivores and carnivores) that comprised total fishes. For carnivores, the analyses explored possible, finer-scale patterns within each of four major feeding guilds (benthic invertebrate-feeders [hereafter referred to as "benthic carnivores"], zooplanktivores, corallivores, and piscivores).

Major analysis results are as follows: An apparent, but insignificant (16 percent), overall decline in total fish abundance resulted from a nominal 10 percent increase in herbivores offsetting a marginally significant ($P \cong 0.05$) decrease in carnivores. The latter primarily reflected a similar decline of about 30 percent in benthic carnivores and was consistent among barrier reef as well as patch reef stations. Apparent decreases at the individual species level, although significant for only four of the 30 most common and abundant species, tended to outnumber increases (20 versus 10; $P=0.05$; binomial test). These data suggest the operation of some broadscale phenomenon (such as a change in oceanographic productivity or transport) that has affected the recruitment and year-class strength of many species.

Overall abundance patterns for herbivores were obscured by large and significant (at 2 twofold; $P<0.05$) shifts in densities from barrier-reef to patch-reef stations between the two sampling periods. Surgeonfishes of the family Acanthuridae, particularly browsers of filamentous benthic algae like the yellow tang, *Zebrasoma flavescens*, dominated the shifts in herbivore distributions. Data indicating temporal increases in filamentous algae at FFS, especially on patch reefs, suggest that the shift in herbivore distributions tracked changes in the distribution of their food resources. At present, data identifying the mechanism causing the apparent shift in algal distributions are lacking. One plausible working hypothesis might be that, as a result of more frequent and intense physical (wave) disturbance during the productive and relatively stormy 1980s, the area of live coral substrate declined in shallow reef habitats at FFS, and algal cover of dead coral rock has consequently increased. Lack of data

on extent of the two types of habitat (barrier reef versus patch reef) at FFS prevents conversion of herbivore densities to abundances.

In summary, the strongest patterns demonstrated by the temporal contrasts of reef fishes at FFS are shifts in herbivore distributions. Available data also are consistent with, but by themselves do not conclusively demonstrate, a more general decline in reef fishes at FFS between the two sampling periods. Data on temporal fluctuations in fish abundances during either sampling period unfortunately are limited to observations at a single patch reef station during 1980-83. Additional data on the relative magnitude of shorter-term temporal patterns (for instance, yearly fluctuations within oceanographic regimes) would be necessary before more definite conclusions are possible.

A summary of these reef fish findings was recently presented by Ed DeMartini of the Insular Ecology Program at the aforementioned "Workshop on Variation in the Marine Environment and Ecosystem around the Hawaiian Archipelago," held at the University of Hawaii's East-West Center on December 3-4, 1992. Data displays are now being produced for a written report, scheduled for completion in winter 1993. (E. DeMartini, [808] 943-1266)

Diurnal Migration and Distribution of Armorhead, *Pseudopentaceros wheeleri*, on Southeast Hancock Seamount.

Since its discovery in 1967 the pelagic armorhead, *Pseudopentaceros wheeleri*, has been the target of Russian and Japanese trawlers on the central North Pacific seamounts. Annual catches of armorhead by the Japanese ranged from 20,000 to 30,000 metric tons (t) in the early to mid-1970s. Descriptions from the fishery reported distinct differences in the day and night catches. Russians first believed that diurnal changes of armorhead catches were related to the aggregation of armorhead up into the water column at dawn and off the summit during the daylight hours to feed on the surface and descend to gather on the summit at night. However, Japanese diet studies have shown that the prey items were associated with the deep scattering layer that would rise to shallower water at night and descend during the day, thus disputing earlier reports by the Russians on armorhead movement.

Since 1978 the Honolulu Laboratory has been monitoring and studying armorhead stocks on Hancock Seamounts using reports made by observers on foreign commercial fishing vessels and research cruises. A part of the study was to understand the disparity of day and night catch rates. The unusual life history of the armorhead makes this work difficult. Spawning occurs at and around the Southern Emperor and Northern Hawaiian Ridge seamounts from November to January. After spending 1½ to 2½ years in the epipelagic zone, from larval to sub-adult stages, armorhead acquire large fat reserves. Upon recruitment to the seamounts, they begin to mature and lose body weight, principally because of their inability to obtain sufficient amounts of prey and because of the consequences of spawning. Armorhead remain on the seamount for about 4 to 5 years to spawn and then die.

Commercial trawlers that fished the Hancock Seamounts from 1978 to 1984 also experienced higher catch rates at night. Using the Leslie and Davis method in which catch-per-unit effort (CPUE) is correlated to cumulative catch relative to the time period, initial abundance, N_o, estimates were significantly higher at night with a lower catchability coefficient, q (Fig. 4). Differences in the day-night N_o estimates indicate about 2 to 28 percent of the stock remains on the summit during the daylight hours and is vulnerable to the gear. Although a smaller proportion of the total population occupied the summit by day, trawls at night were shown to be more effective in reducing the available armorhead stock.

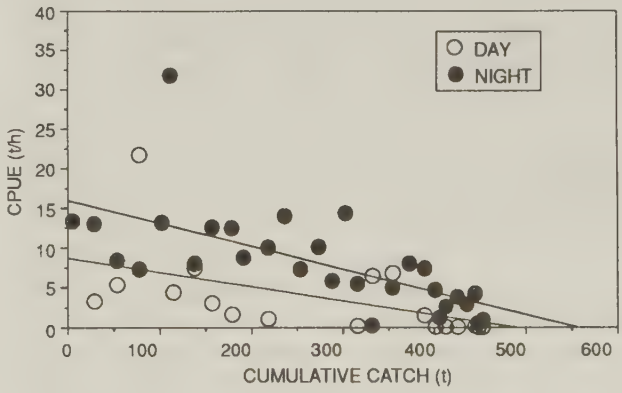

Figure 4. Day and night catch-per-unit effort (metric tons per hour [t/h]) as a function for cumulative catch (t) for one of the commercial trawlers fishing on Southeast Hancock Seamount in 1980.

From 1985 to 1991 the Honolulu Laboratory carried out ten cruises to the Hancock Seamounts, a period when all commercial fishing had stopped because of low catches and the subsequent 1986 fishing moratorium. Stock assessment and re-

search studies were carried out with bottom longline because of its effectiveness and ability to allow fishing beyond the summit flats down the flanks of the seamount.

Armorhead caught during the day were found deeper and over a broader depth range while fish caught at night were concentrated at a mean depth of 295 m, about 10 to 50 m shallower than daytime mean depths. Body condition or fatness index was found to be inversely related to depth. Fatter recruits tended to occupy the near summit depths of 243 m, while leaner, predominantly male, fish were found much deeper.

Fatness index on the summit-caught fish, both trawl and longline (also predominantly male), were found to be lower at night. These changes in the mean fatness index and sex ratio undoubtedly imply migration of the leaner male fish from the flanks to the summit flats at night. The migration of leaner armorhead appears to be in response to feeding on the deep scattering layer. The deep scattering layer begins to rise at dusk. It appears that armorhead are moving up the flanks and onto the summit in response to diurnal migration of prey items. Armorhead then will remain on the summit flat until dawn to prey on the descending scatterers. Diet studies have shown that maximum feeding occurred during the early morning hours, with prey items predominantly from the scattering layer. (B. Kikkawa, [808] 943-1215)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Simulation Model Developed to Project Impacts of Alternative Permit Transferability Rules in the Hawaii-based Longline Fishery.

Robert A. Skillman, fishery biologist of the Pelagic Stock Assessment Program, and Samuel G. Pooley, industry economist of the Fishery Management and Performance Investigation, of the Honolulu Laboratory, recently developed a framework for projecting the impact of alternative permit transferability rules in the Hawaii-based longline fishery. The framework called for developing a simulation based on four steps:

(1) modeling the fishery (number of active and inactive vessels by size-class, proportion of fishing effort in different geographical areas, and species catch rates by geographical area and vessel size-class) using a selected time period (12 month year-to-date) from the historical record;

(2) allocating fishing effort among vessel size-classes in response to potential regulatory changes by having industry experts project the probable impact of alternative permit transfer schemes on the number of active and inactive vessel permits by size-class;

(3) projecting species catch and revenue by vessel size-classes and geographical area, based on the alternative fishing effort allocations developed in the previous two steps; and

(4) comparing projected species catches with actual catches for the selected time period to facilitate evaluation of the potential biological, operational, and economic impacts of the alternative longline fishing vessel permit transferability rules.

The analysis assumes that fishing practices (including choice of target species and area of fishing) are determined exclusively by the size of the vessel although it was recognized that this was a severe simplification of the situation. Table 1 summarizes the fishing practices of the current fleet by size of vessel, target species, and area of fishing.

Summaries were compiled of year-to-date (October 1991-September 1992) logbook data of catch and effort for the Hawaii longline fishery in two areas: inside the main Hawaiian Islands exclusive economic zone (EEZ) and outside the Hawaii EEZ. (To simplify the analysis, fishing in the Northwestern Hawaiian Islands' EEZ and the EEZs of U.S. possessions in the central Pacific were excluded; fishing in the included areas amounted to 93.6 percent of fishing effort [hooks set] during the 12-month period). The latest 12-month year-to-date was chosen as the appropriate time period because (a) 24-month summaries were not available at the time (the logbook program was initiated in mid-November 1990), and (b) there were significant regulatory changes during the early months of the logbook program. Both factors reduce the efficacy of using the early logbook information, while a complete year-to-date analysis covers the full measure of annual seasonality.

A multi-page spreadsheet model was created that made a graphical presentation of the current Hawaii longline fishing situation and alternative fishing patterns. The alternatives could be specified by shifting the number of active and inactive Hawaii longline permit vessels within three size categories. Figure 5 outlines the spreadsheet mechanics and the logical flow of information in the simulation.

Table 1. Fishing effort (1000 hooks set) for the Hawaii longline fleet by size of vessel, area of fishing, and species targeted. Western Pacific longline logbook data (October 1991 - September 1992) compiled by the Fishery Monitoring and Economics Program at the Honolulu Laboratory.

Small-sized vessels (less than 56 feet in length overall)

Area Fished\Target Species	Main Hawaiian Islands	Outside Hawaii EEZ	Other EEZ areas
Broadbill (swordfish)	3.1	101.2	10.6
Tuna	1,666.1	733.9	114.1
Mixed	190.8	42.3	0.0
Total	1,860.0	877.4	124.7

Medium-sized vessels (between 56 feet and 74 feet in length overall)

Area Fished\Target Species	Main Hawaiian Islands	Outside Hawaii EEZ	Other EEZ areas
Broadbill (swordfish)	70.9	726.9	124.0
Tuna	1,354.0	804.1	144.0
Mixed	840.2	977.5	70.3
Total	2,265.1	2,508.5	338.3

Large-sized vessels (greater than 74 feet in length overall)

Area Fished\Target Species	Main Hawaiian Islands	Outside Hawaii EEZ	Other EEZ areas
Broadbill (swordfish)	69.2	1,337.0	162.8
Tuna	210.1	179.3	17.3
Mixed	160.9	1,442.5	101.2
Total	440.2	2,958.8	281.3

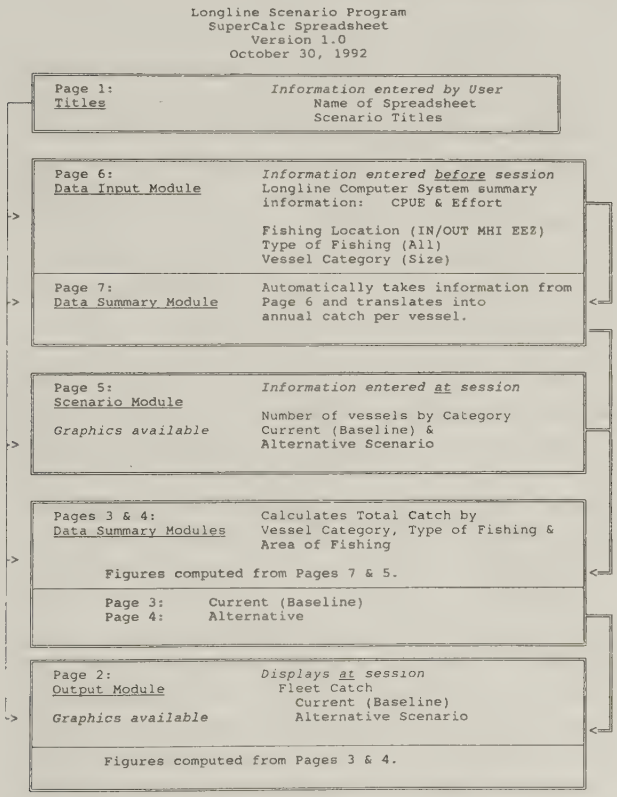

Figure 5. Schematic of spreadsheet program used to generate simulation results.

The simulation model was the main focus of a workshop on permit transferability held at the Honolulu Laboratory on November 12, 1992. The workshop, sponsored and chaired by the Western Pacific Regional Fishery Management Council, was in response to urgent requests by some members of the Hawaii longline fishery to allow transferability of limited entry longline permits. At present, Council rules allow only one transfer in a 3-year period (1992-94), and some longline vessel owners have discovered this has significantly reduced the salability of their vessels.

The workshop was conceived by Laboratory, Council, and NMFS Southwest Region Pacific Area Office staff to combine scientific knowledge of current fishing practices and the potential impact of changes in those practices with industry knowledge of the type of changes in fishing practices that might occur under various permit transferability schemes.

The workshop analyzed four alternatives: the status quo, sale of permit with vessel, one-time sale of permit with one-time upgrade of vessel harvesting capacity, and unrestricted sale permit and upgrading of vessel harvesting capacity.

The simulation created by Skillman and Pooley was rudimentary in its dynamics: changes in catch rates or market prices were not included in the simulation, nor were any changes in fishing costs (due to effort expended outside the EEZ). Changes in fishing practices by size-class (for instance, targeting of different species or shifting effort within or outside the EEZ) were also not included. Incorporating biological or economic dynamics within the simulator framework would be a major undertaking. Use of the simulator for further policy analysis by the Council would warrant sensitivity testing of its results, in which case various parameters (particularly the number of active vessels by size category and in average catch rates) would be varied over a relevant range. These could be carried out rather simply by using the multi-page spreadsheet version of the model and varying its inputs. (S. Pooley, [808] 943-1216)

West Coast and Western Pacific Fisheries Data Committees Hold Joint Meeting in Honolulu

Two fisheries data committees, the west coast Pacific Fishery Information Network (PacFIN) Data Committee, and the Western Pacific Fishery Information Network (WPACFIN) Fisheries Data Coordinating Committee (FDCC), held their first joint meeting on October 20, 1992, in Honolulu, Hawaii. Four PacFIN representatives joined forces with five FDCC representatives to develop recommendations for allocating the FY 93 funds available for operating PacFIN data programs in each state and island area.

The joint committee had the difficult task of reviewing and ranking 24 proposals for projects of considerable importance for meeting current or long-term federal fishery management requirements in the Pacific. Since the FY 93 PacFIN funding available ($1.8 million) was considerably less than the total budget required to fund all of the 24 projects ($2.4 million), a 5-level ranking scheme was used to prioritize the projects and develop a recommendation for the 3 NMFS regional directors responsible for allocating the funds among the projects and agencies. After thorough review of the proposals and much discussion of the details of impacts of cuts, the joint committee developed a recommendation for allocating the funds within the limits of the FY 93 budget.

Participants in this first joint meeting of the PacFIN and WPACFIN data committees agreed that the meeting was very beneficial in understanding the needs of each of the agencies participating in the PacFIN and WPACFIN cooperative data programs. The meeting was successful because it accomplished the goal of developing, for the first time, a joint recommendation from the two data committees for allocating funds among the various agencies.

A Fishery Information Network (FIN) was established over 12 years ago to help monitor and manage fishery resources under U.S. jurisdiction in areas of the Pacific Ocean. This cooperative program is composed of state and federal fisheries agencies on the Pacific coast of the U.S., including Alaska, California, Oregon, and Washington (PacFIN), and similar agencies in the western Pacific areas of American Samoa, Guam, Hawaii, and the Northern Mariana Islands (WPACFIN). To help guide the implementation and operation of these two functionally separate components of the overall Pacific FIN, committees were established in each area with representatives from all the participating state and local agencies, the Regional Fishery Management Councils, the Pacific States Marine Fisheries Committee, and NMFS regions and centers. (D. Hamm, [808] 943-1214)

WPACFIN FDCC Reviews Integrated Data System Applications

The Western Pacific Fishery Information Network (WPACFIN) Fisheries Data Coordinating Committee (FDCC) held its nineteenth meeting on December 3, 1992, at the NMFS Honolulu Laboratory. Although the principal purpose of the meeting was to develop a recommendation for revised FY 93 WPACFIN project proposals to reflect a budget reduced by nearly 50 percent (to $278,000), the Committee also reviewed two fisheries applications of integrated data systems.

The first system demonstrated was the Gulf of Mexico Shrimp Harvest Data Base developed by the Southeast Fisheries Science Center (SEFSC) and the National Ocean Service's (NOS) Office of Oceanography and Marine Assessment using their computer mapping and analysis system technology. This stand-alone application runs on a MacIntosh computer. The system integrates data from three principal commercial shrimp landings data sets to provide the user with a wide array of summaries of shrimp harvest information. The most important feature of the system is the mapping interface that allows the user to quickly display maps of the Gulf of Mexico with user-selected shrimp landings data graphed in statistical areas and depth ranges. The FDCC and WPACFIN will be investigating the po-

tential for a similar application for western Pacific fisheries.

The second system demonstrated was the first phase of the Central WPACFIN On-line Query System (CWOQS, verbalized "sea walks"). Still in its early stages of development, CWOQS is a dial-in system running under the dBASE IV environment on a centrally operated IBM-compatible 486 PC. The basic user-interface shell of this menu-driven system allows the user to select various types of data from among the four WPACFIN island areas (American Samoa, Hawaii, Guam, and the Northern Mariana Islands) and produce either standard or user-defined monthly and annual reports. At the current level of development, only the commercial landings processing module for the Northern Mariana Islands, which integrates four data sets, is functional, but new processing modules are being added as time and resources permit. The design of the full system currently contains modules to process data from over thirty data sets covering all aspects of fisheries monitoring in the exclusive economic zones of the western Pacific. Automated graphical interfacing was not part of the original design of CWOQS, but it is being considered as a definite option for future enhancements. At future meetings, the FDCC will be discussing priorities and proposed schedules for developing and implementing other phases of CWOQS to improve fishery monitoring and data accessibility in the western Pacific. (D. Hamm, [808] 943-1214)

HAWAII REGIONAL COASTWATCH NODE

Data Archive and Analysis System Developed

The Hawaii Regional CoastWatch Node (HRCN) was developed at the Honolulu Laboratory to facilitate accessing and distributing of remote ocean imagery sensing data received by satellite. The node will be connected to Internet in January 1993 through the University of Hawaii's Internet node. After this electronic connection is made, HRCN will start functioning as a fully operational CoastWatch node. Each CoastWatch node has satellite data collection or processing units as well as archiving units, and the nodes will be open to use by local and remote users. This report summarizes the physical and logical structure that HRCN will use to provide remotely sensed data, which initially will be limited to Advanced Very High Resolution Radiometer (AVHRR) data, to both local and remote CoastWatch users.

In planning a data archive and analysis system, primary considerations were given to ease of use and simplicity in development; an equally important consideration was its compatibility to the existing hardware platform and operating system: a SPARCstation 10 and Sun OS 4.1.3. The preliminary data archive and analysis system developed at the HRCN relies heavily on using unix file structure, C shell scripts, local image processing software, and Internet and file transfer protocol (FTP). These tools will be used to support an operating CoastWatch environment on a SPARCstation 10 workstation connected to an Internet node via a 56,000 KBPS Ethernet line.

The HRCN system is simple: similar to other CoastWatch nodes, it relies on the file structure of the operating system to organize data. The CoastWatch unix file structure, shown in Figure 6, serves as a map to help users locate data being archived or stored both on-and off-line. The location of desired data files is given in a catalog directory file. Catalog files are organized by time (for instance, by year), data source (for instance, a satellite sensor), and area or region of interest. Outside users will be able to retrieve data using FTP on Internet. An anonymous FTP account will be created to allow Internet users access to on-line data. Off-line data requests can be made on a limited basis. The location of both on- and off-line data will be given in the catalog files. Users need to read the *catalog* file and request off-line tiles by name and location or access on-line tiles directly. Local users can scan the unix file structure or read the catalog file to see where data exist. These data can be displayed using local image software. Local users can also take a look at the

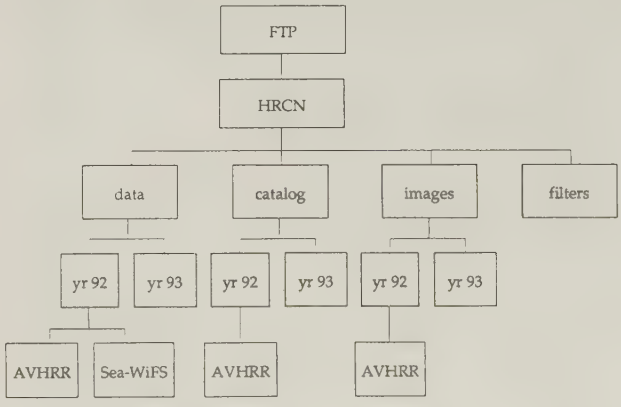

Figure 6. Unix file structure used to organize data at the Hawaii Regional CoastWatch Node (HRCN). FTP = file transfer protocol; AVHRR = Advanced Very High Resolution Radiometer; Sea-WiFS = Sea-viewing Wide Field of View Sensor.

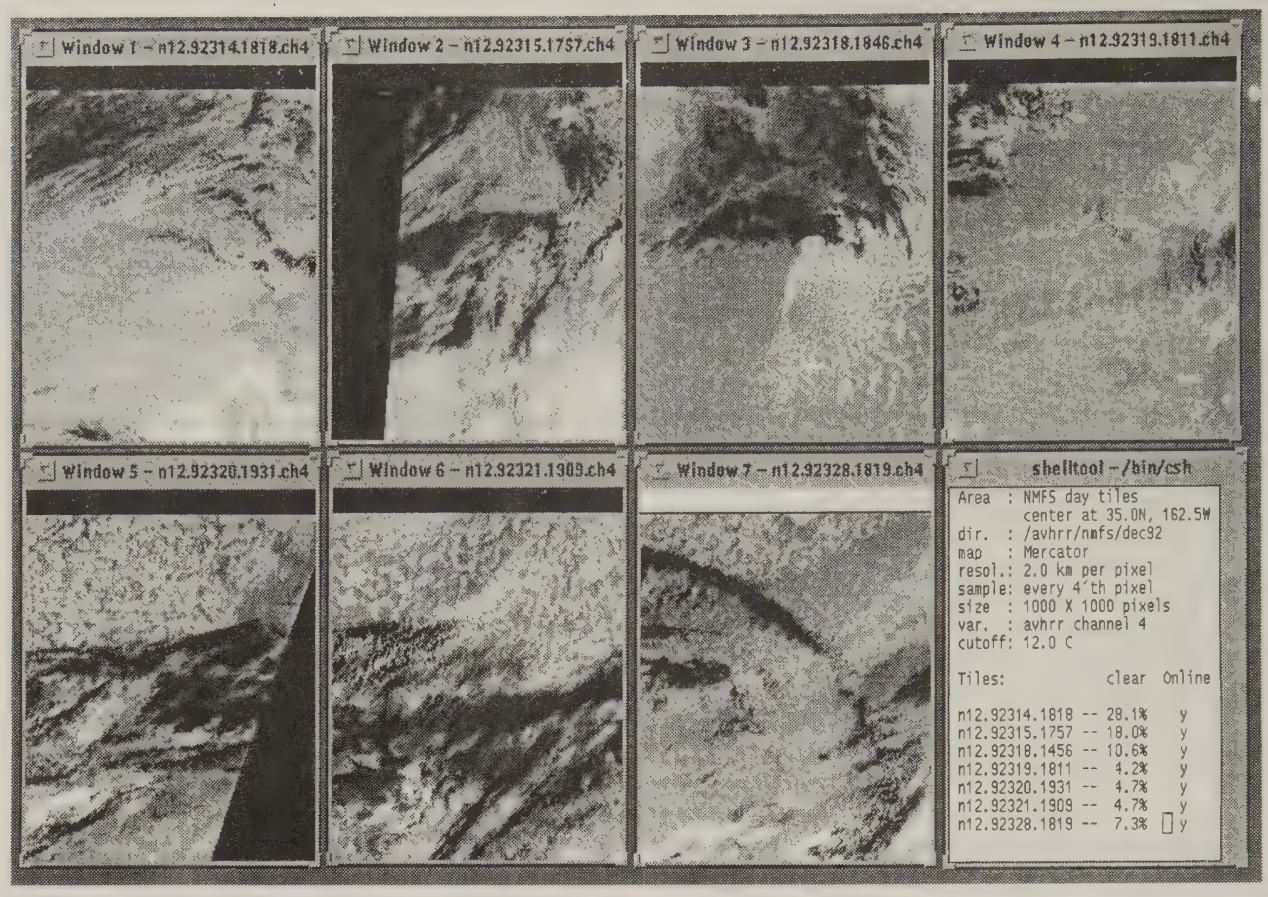
Window 1 – n12.92314.1818.ch4
Window 2 – n12.92315.1757.ch4
Window 3 – n12.92318.1846.ch4
Window 4 – n12.92319.1811.ch4
Window 5 – n12.92320.1931.ch4
Window 6 – n12.92321.1909.ch4
Window 7 – n12.92328.1819.ch4
shelltool – /bin/csh
Area : NMFS day tiles
center at 35.0N, 162.5W
dir. : /avhrr/nmfs/dec92
map : Mercator
resol.: 2.0 km per pixel
sample: every 4'th pixel
size : 1000 X 1000 pixels
var. : avhrr channel 4
cutoff: 12.0 C
Tiles: clear Online
n12.92314.1818 -- 28.1% y
n12.92315.1757 -- 18.0% y
n12.92318.1456 -- 10.6% y
n12.92319.1811 -- 4.2% y
n12.92320.1931 -- 4.7% y
n12.92321.1909 -- 4.7% y
n12.92328.1819 -- 7.3% y

Figure 7. Sample hardcopy browse image.

newly developed *hardcopy browse* directory available in the CoastWatch room; a sample is given in Figure 7.

Future additions will include the use of a PC-based system to allow remote users access with the PROCOMM software. (C. Motell, [808] 943-1279)

PROTECTED SPECIES INVESTIGATION

Hawaiian Monk Seals Relocated in 1992 Rehabilitation Project

In early September, 10 underweight female weaned pups and juvenile monk seals were collected at French Frigate Shoals (FFS) for transport to Midway for rehabilitation and release. The seals were held in a fenced shoreline enclosure at a small beach on the north coast of Tern Island at FFS until they could be transported to Midway. While being maintained at FFS, the seals were tube fed a formula preparation twice daily. All seals were given worming treatments soon after collection. Blood cell counts, serum chemistry profiles, and serum antibody assays for several potential seal diseases were also performed on all the seals soon after they were collected. Negative test findings for disease enabled the relocation to Midway to proceed.

Prior to transport, one seal died at Tern Island, probably from aspiration pneumonia although the origin of the condition is unknown since the seal's morning feeding that day was uneventful, and her behavior that morning was not noticed to be unusual. The remaining nine seals were relocated to Midway on the NOAA ship *Townsend Cromwell* in October. Once on the ship, their diet was changed from formula to herring.

On arrival at Midway, the seals were put into a shoreline fenced enclosure on Sand Island. The seals were offered herring that were put into the water in the enclosure. Seals that did not free feed were force-fed herring until eating on their own. Two yearlings died prior to release. One had never free fed in the enclosure; necropsy and histopathol-

ogy findings did not indicate the cause of death. The second seal died of severe pneumonia following 5 weeks of treatment with several antibiotics. A third seal from this group was found dead after release. It had been free feeding and was considered healthy when released. The cause of death could not be determined.

Two additional deaths were recorded in rehabilitated seals that were released in 1992. One was a yearling that had been collected as a pup at FFS in 1991, rehabilitated at Sea Life Park on Oahu, and released at Midway in June 1992. Another was a yearling collected in May 1992 at FFS, rehabilitated at Kaneohe Marine Corps Air Station on Oahu during the summer and released at Midway in August. The latter two seals were found dead on Eastern Island (one of the Midway group) in November, but postmortem autolysis (a breaking down of all or part of a cell or tissue by self-produced enzymes) prevented assessment of the cause of death.

Some deaths were expected in this rehabilitation effort due to the poor condition of the seals when collected. In spite of the deaths, the collection and relocation of seals directly to Midway worked well with the logistical support of *Townsend Cromwell*. Released seals were tagged and their survival will be monitored and compared with that of seals remaining at FFS. Problems experienced with the seals' health in the direct relocation indicated that veterinary care of other than simple problems cannot be adequately managed in the field due to the infrequent Military Airlift Command (MAC)--now AMC (Air Mobility Command)--flight frequency. To solve this problem, a seal holding facility was constructed at the Kewalo Research Facility (KRF) in December. In the future, seals that become ill while undergoing rehabilitation at Midway will be shipped to the KRF for intensive veterinary care.

In January 1993, the Marine Mammal Research Program staff, with invited veterinary experts, will review the methods and problems that occurred in various forms and that were encountered in the rehabilitation efforts during 1992. This review group will draft a plan for the 1993 Hawaiian monk seal rehabilitation/relocation/release program. (W. Gilmartin, [808] 943-1239)

Hawaiian Monk Seal Movement Patterns Studied Using Satellite Telemetry

The designation of the Hawaiian monk seal, *Monachus schauinslandi*, as endangered (Federal Register, 41 FR 51611) established a clear and urgent need to understand the pelagic ecology of this species. Virtually nothing is known of the movements and distribution of the monk seal at sea, yet such information is vital in understanding its foraging patterns, in predicting its potential for interaction with fisheries, and in determining and protecting its critical habitat. The need to understand the monk seal's behavior and foraging patterns has recently become even more urgent, as the largest population of seals at French Frigate Shoals (Fig. 8) has declined by approximately 20-30 percent in the last 3 years. Since 1989, this population has experienced a marked drop in birth rate and juvenile survival; furthermore, the condition of surviving juveniles has been poor. A number of hypotheses have been considered as possible explanations, but the primary hypothesis suggests the observed changes reflect a decrease in prey availability. Testing this idea requires an understanding of monk seal foraging patterns. Satellite telemetry provides a potential method for studying foraging depths and locations and, by inference, prey preferences.

To evaluate the utility of this method for the study of Hawaiian monk seals, satellite-linked time-depth recorders (SLTDR) were attached to three subadult males in September 1992. These instruments collected and transmitted data on maximum depth and duration of each dive over a period of at least 2 months (two SLTDRs have been retrieved, and one is still attached and functioning). Receivers on board ARGOS satellites calculated the location of each SLTDR from frequency shifts in

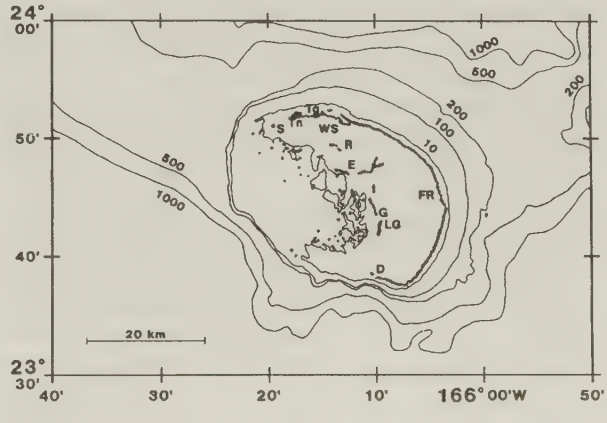

Figure 8. Study area at French Frigate Shoals. Contours are in fathoms. Abbreviations refer to the fringing reef (FR) and the following islands: Shark (S), Tern (Tn), Trig (Tg), Whaleskate (WS), Round (R), East (E), Gin (G), Little Gin (LG), and Disappearing (D).

transmitted signals as the satellites passed overhead. Within a matter of hours, the dive and location data were available to the Protected Species Investigation of the Honolulu Laboratory.

Locations estimated by the satellites vary in accuracy and precision, and (as is the case for any telemetry study) results must be interpreted with caution. However, the algorithm used to calculate location also provides an indication of the accuracy of the final estimate. In this pilot study, estimated locations considered to have a 66 percent or greater chance of being within 1 km of the true location were assumed reliable. Other estimated locations may also have been relatively accurate but, for a variety of reasons, the reliability of these estimates was not determined or known.

Reliable location estimates for all three animals combined ($n = 95$) were clustered around the northern and southern edges of the atoll (Fig. 9). The animals were in the water while approximately 40 percent of these locations were estimated; the remaining 60 percent pertain to locations when they were hauled out on land. These locations suggest that the study seals remained close to the atoll, and rarely ventured out over deeper water.

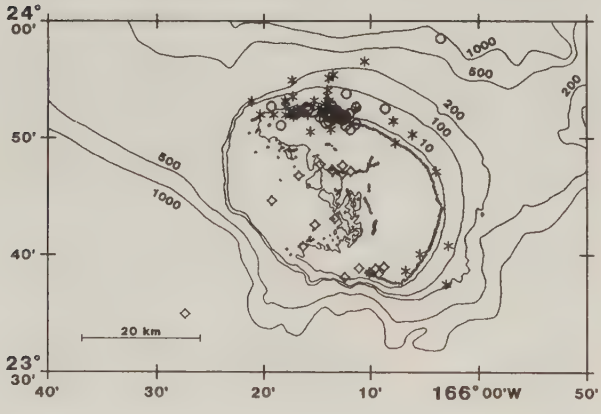

Figure 9. Reliable location estimates for the 3 subadult males instrumented with a satellite-linked time-depth recorder. The 3 plotted symbols correspond to records from the 3 seals. Contours are in fathoms. □, *, and o = individual monk seals.

On the other hand, many of the location estimates of unknown reliability were widely dispersed outside the atoll. One possible explanation for the greater dispersion of this second set of estimates is that they include greater satellite error. While that may be the case, the additional error does not necessarily explain all the observed dispersion. The lack of reliable location estimates farther out at sea may also be explained by other factors, such as variation in animal behavior (for instance, less surface time over deep water, resulting in the reception of fewer signals and less-precise estimates) or sea state (for instance, calmer conditions within or near the atoll). Further analysis should provide a method for determining the reliability of the more dispersed location estimates and resolving this apparent discrepancy.

In addition to estimating locations, the satellites also receive and transmit data on dive depth and duration. The data are stored and transmitted as histograms, and a summary of these depth histograms for one of the subadult males is illustrated in Figure 10. The figure indicates that this individual rarely dove deeper than 76 m, and that its dives were fairly evenly dispersed throughout the 24-hour diurnal cycle. Night dives occur more often between 28-50 m, whereas daytime dives are deeper and occur more frequently between 52-78 m. Similar data are currently being analyzed for the other two study males.

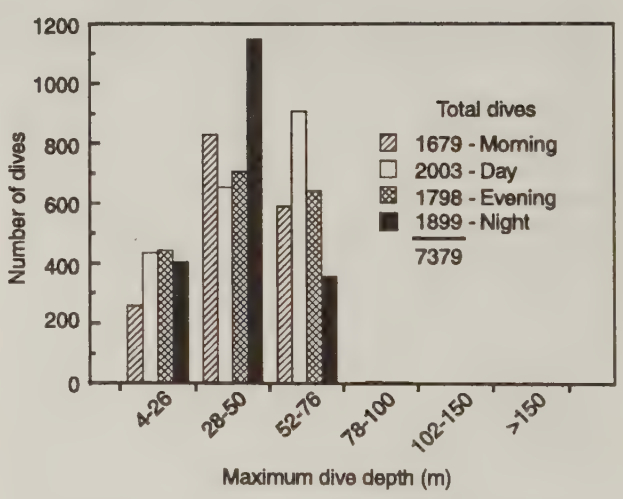

Figure 10. Frequency histogram for maximum depth of dive of one subadult male monk seal, as determined from satellite telemetry records collected over 66 days (on average, 110 dives per day).

Monk seal diving patterns have been investigated in earlier studies, but these studies did not have the advantage of newer technology that can also provide information on seal location. Hence, this technology should considerably advance our understanding of monk seal pelagic ecology. After years of land-based study of Hawaiian monk seals,

satellite telemetry offers the first real opportunity to study the pelagic movements and distribution of this endangered species. (T. Ragen, [808] 943-1280)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Tuna Movement Model Developed

During his stay at the South Pacific Commission (SPC) in Noumea, New Caledonia, last year, Fishery Biologist Pierre Kleiber and SPC scientist John Hampton developed a tuna movement model in which movement is affected by aggregating factors such as fish aggregating devices (FADs) or islands. Their first examination of the model's performance was with skipjack tagging data from the Solomon Islands (See *Southwest Fisheries Science Center Report of Activities* for July-August 1992). As a follow up to that work, Kleiber has been refitting the model under different conditions to help confirm conclusions that the data indicate movements associated with the presence of FADs around the Solomon Islands. To make the analytical process somewhat easier, Kleiber is developing a way to have S-plus orchestrate the data-fitting procedure.

S-plus is a statistics and graphics program that provides great facility in data visualization and data analysis, and it includes a choice of model fitting functions. Hence, it is quite advantageous to conduct the fitting and exploring with S-plus. The problem is the burdensome task of recoding the movement model directly in the S-plus language. The model is complex, is written in C++ and takes advantage of some of the unique features of that language, but C++ is not compatible with S-plus. Furthermore, the recoded model would run much too slowly.

To overcome that difficulty, Kleiber consulted with experts of S-plus and developed an S-plus function that actually communicates with a model that is running on C++, but as a separate process from S-plus. Thus, the model can remain coded in C++, but still be analyzed with S-plus. The procedure takes advantage of inter-process communication features of the UNIX operating system.

So far, Kleiber has implemented a working prototype with a simple test model and will shortly have the tuna movement model working in this way. With some enhancement of the scheme, a model process and S-plus could even be run on a different machine connected by a network. The model could run on the Cray super computer, for example. This would facilitate fitting very long-winded models or doing Monte Carlo investigations with somewhat shorter-winded models. (P. Kleiber, [619] 546-7076)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Swordfish Gonads Examined

Fishery Biologist Darlene Ramon examined gonads from swordfish captured in the seasonal (July through January) driftnet fishery off California for reproductive development. During the fishing years 1990 to 1992, National Marine Fisheries Service observers on board the fishing vessels collected gonads from a total of 677 swordfish.

The sex ratio of males to females (M:F) was 0.78:1. Ovarian tissue from a subset of 72 females was prepared for histological examination. The tissues were graded for developmental stages. None indicated current spawning, such as presence of yoking eggs or hydrated oocytes. Three developmental states were identified: immature, early developing, and developing.

Some evidence of atresia, the absorption of eggs, was found in the form of black masses containing oocytes that were being absorbed. The presence of atresia suggests that some fish may have been in spawning condition within the past few months. However, because the rate at which oocytes are absorbed is unknown, more precise estimates of when spawning occurred cannot be made without further study. It is known that spawning occurs year-round because swordfish larvae are found at all times of the year in tropical and sub-tropical waters. The peak period of spawning, however, may be shorter, (for instance, April-July, in the North Pacific) and individual fish may not spawn year-round.

Based on these findings, further analysis of swordfish reproduction should be conducted using samples taken from the spawning areas rather than from southern California. (D. Ramon [619] 546-7074)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATION

Hurricane Damage To Reefs Assessed

Although the hurricane that struck the Hawaiian Islands during September passed more than 100 miles off the Kona Coast of the island of Hawaii, it inflicted major damage in certain areas of the Kona reefs. This was the finding of Fishery Biologists Ted Hobson, Tony Chess and Dan Howard, who visited the site in early October, 3 weeks after the storm. The Groundfish Communities Investigation, in a project sponsored by the Honolulu Laboratory, has monitored communities on specific reefs at this location since 1978, and this visit was a regularly scheduled event.

The damage from the storm was highly localized, with only minor effects noted on the long-term study sites; in fact, the condition of the reefs at these sites may have been enhanced by the removal of sediments that had been settling in several places. However, a location that had been monitored since 1988 (by Dan Howard for a supplemental study of echinoid-reef algae relations) was devastated. This was an area covered by the coral *Porites compressa* on the outer reef slope, where transects had been established at depths of 10, 12, 15, 18 and 21 m. (In comparison, the nearby primary site on the nearby reeftop is at depths of 5 to 12 m.) It is significant that the damage was mainly at depths below 15 m (Fig. 1). Presumably this is because surge from surface waves rarely extends that deep, so the corals there have had no reason to develop tolerance of water movement.

Figure 1. Transect line at 15 m on the outer reef slope of the Kona reefs off the Kona Coast of Hawaii, showing that damage from the September 1992 hurricane-generated surge was most evident on the deeper area of the reef.

In contrast, *P. compressa* on shallower parts of the reef frequently experiences surge from surface waves, and obviously can withstand even unusually strong wave surge in that setting. Damage there generally resulted when insecurely anchored heads of another coral, the massive *Porites lobata*, were toppled and then rolled around to crush their more fragile relatives. Another source of damage in the shallower region developed where great loads of debris washed off reeftops to cover living corals in the adjacent areas. (E. Hobson, [415] 435-3149)

GROUNDFISH ANALYSIS INVESTIGATION

Progress Made on Shortbelly Rockfish Biomass Estimate

For the past two years, members of the Groundfish Analysis Investigation have been engaged in a pilot study to evaluate the egg production method (pioneered at the La Jolla Laboratory) as a fishery-independent means to assess the biomass of the spawning stock of shortbelly rockfish, *Sebastes jordani*, inhabiting central California. This is the first attempt to use the method for live bearers like rockfish and for our use, should probably be renamed the larval production method. The method requires estimates of the number of 0-day-old larvae, as well as information on the daily production of larvae per-unit weight of adults. This effort, which is now starting to bear fruit, has broken new ground in the fields of taxonomy and statistics, but it has also made use of some tried and true fisheries techniques.

The primary collections for this project were performed aboard the research vessel *David Starr Jordan* during the height of the spawning season from February 6-19, 1991. Samples with a 0.505-mm mesh bongo net were taken following California Cooperative Oceanic Fisheries Investigations (CalCOFI) procedures at 152 stations between Monterey and Pt. Reyes. Oblique tows were made no deeper than 141 meters, which is shallower than the 212-m maximum on CalCOFI cruises. Data on depth distribution of shortbelly larvae were collected aboard *David Starr Jordan* during February 21-23, 1992. Twenty-one stations were sampled

with a 1 m^2 Multiple Opening/Closing Net and Environmental Sensing [sampling] System (MOCNESS), configured to sample from two to seven strata, depending on water depth. This system allows discrete depth strata to be sampled, whereas a bongo net collects a sample integrated throughout the water column. Oceanographic data were also taken at stations that bounded the area where the plankton samples were taken. Temperature and salinity profiles were collected on CTD casts, and ocean currents were measured with an Acoustic Doppler Current Profiler (ADCP).

Two cruises were fielded to obtain information on the amount of larvae produced per unit weight of *S. jordani*. The first cruise occurred during early February 1991 aboard the chartered commercial fishing vessel *New Janet Ann*. Collections were made with both midwater and bottom trawl gear. The second was a cooperative study aboard the Soviet research vessel *Novodrutsk*, which took place from March 13-21, 1991. Sampling aboard the Soviet vessel was conducted with a midwater trawl. Locations sampled by the chartered vessel were primarily near the Pioneer and Ascension submarine canyons, while the Soviet vessel ranged from Pt. Sur to Bodega Bay.

Laboratory identification of ichthyoplankton collected on the February 1991 bongo cruise and the 1992 MOCNESS cruise has been completed. Specimens from 150 bongo samples were classified as follows (number of individuals shown in parentheses): *S. jordani* (17,392), other rockfish (10,721), sanddabs (1,026), hake (2,968), other fish (23,168). On 30 of these tows, 0.333-mm mesh samples were also taken and analyzed to evaluate the efficiency of the 0.505-mm net. Work-up of the MOCNESS samples involved sorting the contents of 76 nets from 21 tows using the same criteria as established for the bongo samples.

Identification of specimens has been performed in collaboration with the Ecology and Systematics of Fishes Group of the Coastal Fisheries Resources Division at the La Jolla Laboratory. This work has resulted in the description of aberrant pigment patterns found in a small proportion of *S. jordani* larvae and in the development of taxonomic series for larvae of a few species of rockfish that have not previously been completely described in the literature.

Daily ages of over 2000 shortbelly rockfish from the February 1991 bongo cruise have been determined. The ageing subproject required the development of new computerized techniques for handling large amounts of data as well as tracking project progress and monitoring the comparability of different agers.

Yearly age determinations, as well as length/weight measurements, have been made for the adult *S. jordani* collected during February and March of 1991. Batch fecundity and spawning frequency have been estimated by the Groundfish Physiological Ecology Investigation at the Tiburon Laboratory.

Through the analytical program, the researchers have become familiar with spatial statistics (such as kriging), which are being contrasted to more conventional estimation methods such as the Sette-Ahlstrom method. The spatial distribution of larvae of different ages has also been described, allowing researchers to pinpoint centers of spawning activity and subsequent dispersion.

While good progress has been made applying the egg production method to a viviparous species, more information still needs to be developed on the biology of *S. jordani*. The success at ageing these fishes has allowed the development of a very precise estimate of the number of "day-0" shortbelly rockfish in the study region. However, the data indicate that the first visible ring may not be formed one day after parturition and that the number of 0-day-old fish may be overestimated. To resolve this issue, closer scrutiny of the otoliths with a scanning electron microscope and some mathematical modeling is planned. The scientists have yet to obtain sufficient information on the reproductive biology of *S. jordani* to produce an accurate biomass estimate. By collecting samples over a longer span of the spawning season, more samples will be available for analysis and the researchers will be able to better estimate the duration of the spawning season.

Future plans call for field work designed to allow the scientists to begin sampling earlier and for a longer period of time than during previous samples. During 1993, nearly simultaneous collections of larvae and adult *S. jordani* will be made on a 12-day cruise in February. Close collaboration is also planned with investigators at the Moss Landing Marine Laboratory, who are conducting similar research over a more restricted geographic scale and broader temporal period. The collaboration should provide more complete information on the patterns of spawning than has previously been available. (D. Roberts, [415] 435-3149)

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Study Initiated to Assess the Physiologic Status of Rockfish Embryos as Indicator of Reproductive Success

Speculation has existed for some time about the feasibility of using measures of egg quality to predict reproductive success in oviparous teleosts. Within the published literature, mostly with species of aquaculture interest, the results to date have been variable. A synthesis of main findings suggests that certain morphometric, energetic, metabolic and histological features are potential candidates for constructing a model to estimate the vitality of the spawn. Valid estimates of the physiologic status of progeny at spawning could enhance the assessment of year-class strength by providing an indication of the potential for survival and growth. Additionally, the Tiburon scientists' 7 years of investigation of the reproductive biology of yellowtail rockfish, *Sebastes flavidus*, revealed that the nutritional state of ovaries during embryogenesis (January to March) appeared to correlate with the catch of juveniles in May and June. These tenets provide the basis for studying the physiological status of embryos within the ovaries of species of the viviparous genus *Sebastes*.

The study is designed to produce data on a suite of variables from intraovarian embryos that can be used (1) to determine the range of intraspecies variation, (2) for interspecies comparisons, (3) to relate to quantitative measures of year-class strength interannually, and (4) to associate with biotic and abiotic environmental factors. During the coming reproductive season, January through March 1993, species assessed will include representatives of diverse life strategies that comprise the primary components of the catch during the yearly juvenile cruise (May-June) or are part of continuing studies. The scientists plan to evaluate ovaries and embryos from shortbelly, *Sebastes jordani*, yellowtail, *S. flavidus*, and blue, *S. mystinus*, rockfish.

The adults will be subjected to routine morphometric examination (for example, length, weight, age, and relative tissue mass [gonadosomatic index, liver somatic index, and mesenteric fat index]) and ovary tissue and embryos will be excised and evaluated chemically and by image analyzer.

The scientists plan to record variations of morphology from image analysis of embryo size, stage of development, relative proportions of oil, yolk, and embryonic tissue, and the extent of abnormalities or resorption. Biochemically, the scientists will evaluate energy-containing and structural components required for growth. They intend to measure embryonic content of water, lipid, and protein. Lipids will be fractionated and quantified by class (for example, esters, triacylglycerols, nonesterified fatty acids, cholesterol, and polar lipids) and yolk protein utilization will be measured by polyacrylamide gel electrophoresis. It is also hoped that assays for quantifying nucleic acids (RNA, DNA) and adenine nucleotides can be made operational and incorporated into the assessment of embryo growth and energy potential. (B. MacFarlane and M. Bowers, [415] 435-3140)

Project Initiated to Evaluate the Physiological Condition of Young-of-the-year Shortbelly Rockfish

Starting in February 1993, the Groundfish Physiological Ecology Investigation (GPEI) will evaluate the physiological and nutritional conditions of young-of-the-year (YOY) shortbelly rockfish, a groundfish species of potential commercial importance. These measures will be combined with environmental, abundance, and distribution data to enhance the determination of year-class strength. A better understanding of physiological status during the first year of life can improve estimation of a year-class' probability for survival and potential for growth. Physiological condition measures can assess YOY success in acquiring adequate nutrition, which is related to environmental conditions that enable the species to avoid starvation and reduce its susceptibility to predation.

Fishery Biologist Elizabeth Norton plans to collect shortbelly rockfish on three research cruises per year to obtain larval stages in February through juvenile stages in June, along with ambient environmental data. On the GPEI cruise in February, bongo tows will be used to obtain the earliest identifiable larval stages, whereas the MIK (Methot-Isaacs-Kidd) net will be employed to collect later stages in March. In May/June, juveniles will be collected using a midwater trawl. All YOY will be taken in waters off the central California coast from Monterey north to Point Reyes in nearshore to offshore locations.

Physiological condition measures of various stages of development will be followed temporally within a year-class in addition to interannual comparisons to determine if larval growth and condition are affected by environmental changes on seasonal and annual bases. Spatial comparisons

will be made between YOY caught in nearshore and offshore waters to determine if the condition varies in relation to location within the upwelling system. Also, these data will be analyzed along with Groundfish Analysis Investigation's abundance and distribution data to estimate year-class health as well as abundance.

Laboratory analysis will include lipid class separations and total lipid quantification in addition to calorimetry, length, weight, protein concentration, and age measurements. Total lipid and lipid class separations will provide an assessment of the content and ratio of energetic to structural lipids, a measure of energy reserve in the fish. Lipid component analysis, facilitated by automated thin-layer chromatography, can provide a mechanism for rapid, sensitive evaluation of YOY condition on a relatively large number of specimens.

Norton also plans to continue to assess juvenile yellowtail rockfish physiological condition measures that were started in 1990, with the hopes of adding additional rockfish species. (E. Norton, [415] 435-3140)

INFORMATION TECHNOLOGY SERVICES

Transition Plans Developed for the NMFS IT-95 Distributed Systems

The National Data Management Committee met during the week of November 2 at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts, to develop transition plans for the IT-95 distributed systems under procurement. Attending were the Regional Data Base Administrators (RDBA) Ted Rodgers (Alaska Fisheries Science Center), Dorothy Roll (Southwest Fisheries Science Center), MaryAnne Treadway (Southeast Fisheries Science Center), Joan Palmer and alternate Gene Heyerdahl (Northeast Fisheries Science Center), and Michael Fraser and Hugh Johnson (National Marine Fisheries Service [NMFS] headquarters). Johnson, newly hired to be in charge of the IT-95 project, replaced Jim Sargent, who transferred to the Fisheries Statistics Division earlier this year.

Prior to this meeting, each RDBA had drafted a report on the implementation plans for the systems targeted for their regional area. For the SW Regional Area, the report addressed the three "host" systems and the nine scientific work stations for the laboratory sites at La Jolla, California; Honolulu, Hawaii; and Monterey, California. The report specified the site preparation plans and recurring operational costs, the software applications and data conversion plans and costs, and training facilities plans and training costs.

Fraser led the committee in reviewing the regional implementation plans, the first year implementation costs, and the estimated recurring annual costs. Based on these costs in relation to the critical budget constraints, the committee developed the options for implementing the IT-95 systems at the nine targeted sites: Sand Point at Seattle, Washington; Miami, Florida; NMFS Headquarters; La Jolla, California; Honolulu, Hawaii; Woods Hole, Massachusetts; Auke Bay, Alaska; Montlake at Seattle, Washington; and Monterey, California. The committee reviewed the options and then unanimously agreed on the recommended option to be presented to the Regional and Science Directors for their endorsement at the meeting to be held in mid-January. In addition to the recommended option, Fraser's proposed distribution of the Year-0 funds to the regional sites will be presented to the Directors for their endorsement. The distribution of the Year-0 funds, approved by the committee, would provide the resources to startup the training of key users on the use of the relational data base software in preparation for the redesign of the priority data base systems and the conversion of application software. (D. Roll, [619] 546-7057)

Status on the NMFS IT-95 Distributed Systems Procurement Reported

In October NMFS Headquarters received the certified benchmark tests for the IT-95 system proposals from the vendors. These tests were reviewed for compliance by the benchmark team who are also members on the Technical Advisory Committee (TAC). Donald Tieman for the Honolulu Laboratory represents the SW regional area as the benchmark team member on the TAC.

During November, live benchmark tests, the Operational Capabilities Demonstration, were held at all the vendors' sites. Upon completion of these tests, the TAC met in Silver Springs at NMFS Headquarters during the week of December 7. By consensus, the committee developed the final rating of the vendors' technical proposals for recommendation to the Source Evaluation Advisory Board (SSAB). Dorothy Roll represents the SW regional area on this board.

Before the recommendation is submitted to the SSAB, the cost of the systems must be factored into the technical evaluations. Currently, the second of two cost amendments has been sent to the vendors. Basically, these amendments require the vendors to submit updated cost proposals based on the upgrading of the Silver Spring site from a small to a medium system, the changing of some of the desirable software to mandatory optional, and the dropping of certain esoteric software packages. The new cost proposals are due in NMFS headquarters on January 19. (D. Roll, [619] 546-7057)

1992 PUBLICATIONS

Published

This **Published** list encompasses publications for the year 1992 for the Southwest Fisheries Science Center, as of press time (January 1993). Abstracts are provided for those publications being listed for the first time (not listed in previous 1992 Reports of Activities).

Ackman, R. G., T. Takeuchi, and G. H. Balazs. 1992. Fatty acids in depot fats of green turtles, *Chelonia mydas*, from the Hawaiian Islands and Johnston Atoll. Comp. Biochem. Physiol. 102B(4):813-819.

Adams, P. B. 1992. Brown rockfish. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 127-128. California Sea Grant Extension Publication UCSGEP-92-12.

————————. 1992. Canary rockfish. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, p. 129. California Sea Grant Extension Publication UCSGEP-92-12.

————————. 1992. Copper rockfish. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, p. 128. California Sea Grant Extension Publication UCSGEP-92-12.

Adams, P. B., and J. E. Hardwick. 1992. Lingcod. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 161-164. California Sea Grant Extension Publication UCSGEP-92-12.

Anderson, D. W., D. G. Ainley, H. R. Charter, K. T. Briggs, and A. D. MacCall. 1992. Marine bird resources. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 221-225. California Sea Grant Extension Publication UCSGEP-92-12.

Arthur, P. G., T. G. West, R. W. Brill, P. M. Schulte, and P. W. Hochachka. 1992. Recovery metabolism of skipjack tuna, *Katsuwonus pelamis*, white muscle: rapid and parallel changes in lactate and phosphocreatine after exercise. Can. J. Zool. 70:1230-1239.

Atkinson, S., and W. G. Gilmartin. 1992. Seasonal testosterone pattern in Hawaiian monk seals, *Monachus schauinslandi*. J. Reprod. Fert. 96:35-39.

Blood samples from four captive male Hawaiian monk seals were collected at intervals of one month for one year for testosterone assay. Plasma testosterone concentrations, measured by radioimmunoassay, revealed a clear seasonal pattern. The lowest mean testosterone concentration (0.09 ± 0.04 ng ml^{-1}) occurred in January, and the highest (1.78 ± 0.40 ng ml^{-1}) in June. The seasonal occurrence of births and of injuries related to mating in wild populations of Hawaiian monk seals showed a distinct association with the period of high testosterone. This study supports other data which indicate that the Hawaiian monk seal is a seasonal breeder and is reproductively active for longer than monachine seals that live in higher latitudes.

Ballance, L. T. 1992. Habitat use patterns and ranges of the bottlenose dolphin in the Gulf of California, Mexico. Mar. Mammal Sci. 8(3):262-274.

Banish, L. D., and W. G. Gilmartin. 1992. Pathological findings in the Hawaiian monk seal. J. Wild. Dis. 28(3):428-434.

Barlow, J. 1992. Nonlinear and logistic growth in experimental populations of guppies. Ecology 73(3):941-950.

Barnes, J. Thomas, Larry D. Jacobson, Alec D. MacCall, and Patricia Wolf. 1992. Recent population trends and abundance estimates for the Pacific sardine, *Sardinops sagax*. Calif. Coop. Oceanic Fish. Invest. Rep. 33:60-75.

Five different analytical approaches and several sources of data were used to investigate current sardine abundance and recent changes in population size. Each analysis and all available information show an increasing trend in sardine abundance since the late 1970s. Current estimates indicate that the 1990 spawning biomass fell within the range of 60,000 to 210,000 metric tons. Greater precision may be required for population estimates as a commercial fishery develops. The scientists suggest that an integrated method of stock assessment that combines fishery-dependent and fishery-independent data will best meet future stock assessment and management needs.

Bence, J. R., D. Roberts, and W. H. Lenarz. 1992. An evaluation of the spatial distribution of fishes and invertebrates off Central California in relation to EPA study areas with emphasis on midwater ichthyofauna. Report prepared for EPA Region IX, San Francisco, California.

Boehlert, G. W., W. Watson, and C. L. Sun. 1992. Horizontal and vertical distributions of larval fishes around an isolated oceanic island in the tropical Pacific. Deep-Sea Res. (39)3/4:439-466.

Bowen, B. W., A. B. Meylan, J. P. Ross, C. J. Limpus, G. H. Balazs, and J. C. Avise. 1992. Global population structure and natural history of the green turtle, *Chelonia mydas*, in terms of matriarchal phylogeny. Evolution 46(4):865-881.

Bowers, M. J. 1992. Annual reproductive cycle of oocytes and embryos of yellowtail rockfish, *Sebastes flavidus* (family Scorpaenidae). Fish. Bull., U.S. 90:231-242.

Brill, R. W. 1992. The Kewalo Research Facility, 1958-62: Over 30 years of progress. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-171, 41 p.

Brill, R. W., P. G. Bushnell, D. R. Jones, and M. Shimizu. 1992. Effects of acute temperature change, *in vivo* and *in vitro*, on the acid-base status of blood from yellowfin tuna, *Thunnus albacores*. Can. J. Zool. 10:654-662.

Buck, L. T., R. W. Brill, and P. W. Hochachka. 1992. Gluconeogenesis in hepatocytes isolated from the skipjack tuna, *Katsuwonus pelamis*. Can. J. Zool. 70:1254-1257.

Bushnell, P. G., and R. W. Brill. 1992. Oxygen transport and cardiovascular responses in skipjack tuna, *Katsuwonus pelamis*, and yellowfin tuna, *Thunnus albacares*, exposed to acute hypoxia. J. Comp. Physiol. B 162:131-143.

Choy, B. K., and L. M. Hiruki. 1992. The Hawaiian monk seal and green turtle at Pearl and Hermes Reef, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-175, 18 p.

Clarke, R. P., S. S. Yoshimoto, and S. G. Pooley. 1992. A bioeconomic analysis of the Northwestern Hawaiian Islands lobster fishery. Marine Resource Economics 7:115-140.

Several surplus production-based bioeconomic models are applied to the Northwestern Hawaiian Islands (NWHI) commercial lobster fishery. The model which best explains the biological dynamics of the fishery is a modification of the Fox model developed by the authors. Economic costs are applied within a number of conceptual frameworks to develop the first integrated cost of labor based on crew share at the open access equilibrium level of fishing effort is used instead of proxy wage levels. Given the costs incurred, the fishery appears to be self-regulating in terms of long-term fishing effort for maximum sustainable yield.

Conlan, K. E., and J. R. Chess. 1992. Phylogeny and ecology of a kelp-boring amphipod, *Peramphithoe stypotrupetes*, new species (Corophioidea Ampithoidae). J. Crustacean Biol. 12(3):410-422.

Conrad, J. M. 1992. A bioeconomic model of the Pacific whiting. Bull. Math. Biol. 54(2/3):219-239.

Dayton, P. K., and A. D. MacCall. 1992. Pre-exploitation abundances of important large recreational and commercial fishes off southern California. *In* California Sea Grant, Biennial Report of Completed Projects 1988-90, pp. 91-96. California Sea Grant College, University of California, La Jolla, California.

Records of the largest fish caught each year have been kept since 1898 by the Tuna Club in Avalon, Santa Catalina Island, California. This information, combined with historical fish landings data, kept since 1916 by the State of California, allow estimation of the natural mortality rates and pre-exploitation population sizes of two species: white seabass, *Atractoscion nobilis*, and yellowtail, *Seriola lalandei*. Estimates were made by the method of maximum likelihood based on an age- and size-specific demographic model of the population. Initial population size of white seabass was estimated to be 20,000 tons (CV=0.4), and natural mortality rate was estimated to be $0.08yr^{-1}$ (CV=0.15). Initial population size of yellowtail was also about 20,000 tons, with better precision (CV=0.12); natural mortality rate was $0.09yr^{-1}$. A third species, giant seabass, *Stereolepis gigas*, was not amenable to this approach, but is unlikely to have been much greater than the sum of annual landings, about 1300 tons.

Edwards, E. F., and P. C. Perkins. 1992. Power to detect linear trends in dolphin abundance: estimates from tuna-vessel observer data, 1975-89. Fish. Bull., U.S. 90(3):625-631.

Everson, A. R., R. A. Skillman, and J. J. Polovina. 1992. Evaluation of rectangular and circular escape vents in the Northwestern Hawaiian Islands lobster fishery. N. Am. J. Fish. Manage. 12:161-171.

Farrell, A. P., P. S. Davie, C. E. Franklin, J. A. Johansen, and R. W. Brill. 1992. Cardiac physiology in tunas. I. *In vitro* perfused heart preparations from yellowfin and skipjack tunas. Can. J. Zool. 70:1200-1210.

Fiedler, P. C., F. P. Chavez, D. W. Behringer, and S. B. Reilly. 1992. Physical and biological effects of Los Niños in the eastern tropical Pacific, 1986-1989. Deep-Sea Res. 39:199-219.

Gerrodette, T., M. P. Craig, and T. C. Johanos. 1992. Human-assisted fostering of Hawaiian monk seal pups. 'Elepaio 52(7):43-46.

Hanan, D., and J. Sisson. 1992. Pinnipeds. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 208-211. California Sea Grant Extension Publication UCSGEP-92-12.

Henry, F. D., and N. C. H. Lo. 1992. Dover sole. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 97-99. California Sea Grant Extension Publication UCSGEP-92-12.

Hill, S. P., and J. Barlow. 1992. Report of a marine mammal survey off the California coast aboard the research vessel *McArthur*. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-169, 103 p.

Hiruki, L. M., and T. J. Ragen. 1992. A compilation of historical monk seal, *Monachus schauinslandi*, counts. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-172, 200 p.

Holland, R. C. 1992. A program for the Microsoft Windows environment to collect analog-to-digital and serial communication data on a personal computer-based system. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-170, 15 p.

Holland, K. N., R. W. Brill, R. K. C. Chang, J. R. Sibert, and D. A. Fournier. 1992. Physiological and behavioral thermoregulation in bigeye tuna, *Thunnus obesus*. Nature 358:410-412.

Holts, D. B. 1992. Blue shark. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 53-54. California Sea Grant Extension Publication UCSGEP-92-12.

————. 1992. Sharks, skates, and rays: discussion. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 59-60. California Sea Grant Extension Publication UCSGEP-92-12.

Howard, D. 1992. Kelp greenling. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 164-165. California Sea Grant Extension Publication UCSGEP-92-12.

Hunter, J. R., B. J. Macewicz, N. C. H. Lo, and C. A. Kimbrell. 1992. Fecundity, spawning, and maturity of female Dover sole, *Microstomus pacificus*, with an evaluation of assumptions and precision. Fish. Bull., U.S. 90:101-128.

Jacobson, L. D., and S. L. Owen. 1992. Thornyheads. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 132-133. California Sea Grant Extension Publication UCSGEP-92-12.

Jessen, P. F., S. R. Ramp, C. A. Collins, N. Garfield, L. K. Rosenfeld, and F. B. Schwing. 1992. Hydrographic and acoustic doppler current profiler (ADCP) data from the Farallones shelf and slope study, February 13-18, 1991, Naval Postgraduate School Technical Report NPS-OC-92-003. 168 p.

————. 1992. Hydrographic and acoustic doppler current profiler (ADCP) data from the Farallones shelf and slope study, May 16-21, 1991, Naval Postgraduate School Technical Report NPS-OC-92-004. 170 p.

Jessen, P. F., S. R. Ramp, L. K. Rosenfeld, C. A. Collins, N. Garfield, and F. B. Schwing. 1992. Hydrographic and acoustic doppler current profiler (ADCP) data from the Farallones shelf and slope study, February 7-17, 1992, Naval Postgraduate School Technical Report NPS-OC-92-005. 139 p.

Jessen, P. F., S. R. Ramp, C. A. Collins, N. Garfield, L. K. Rosenfeld, and F. B. Schwing. 1992. Hydrographic and acoustic doppler current profiler (ADCP) data from the Farallones shelf and slope study, October 29 - November 3, 1992, Naval Postgraduate School Technical Report NPS-OC-92-007. 166 p.

Keen, J. E., A. P. Farrell, G. F. Tibbits, and R. W. Brill. 1992. Cardiac physiology in tunas. II. Effect of ryanodine, calcium, and adrenaline on force-frequency relationships in atrial strips from skipjack tuna, *Katsuwonus pelamis*. Can. J. Zoo. 70:1211-1217.

Kope, R. G. 1992. Optimal harvest rates for mixed stocks of natural and hatchery fish. Can. J. Fish. Aquat. Sci. 49(5):931-938.

Kusher, D. I., S. E. Smith, and G. M. Cailliet. 1992. Validated age and growth of the leopard shark, *Triakis semifasciata*, with comments on reproduction. Environ. Biol. Fishes 35:187-203.

Laidig, T. E., and D. E. Pearson. 1992. Documentation of three computer programs used to assess daily age from the hard structures of animals. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-168, 44 p.

Laurs, R. M., and R. C. Dotson. 1992. Albacore. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 136-138. California Sea Grant Extension Publication UCSGEP-92-12.

Lenarz, W. 1992. Shortbelly rockfish. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 126-127. California Sea Grant Extension Publication UCSGEP-92-12.

————. 1992. Widow rockfish. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 125-126. California Sea Grant Extension Publication UCSGEP-92-12.

Lo, N. C. H., J. R. Hunter, H. G. Moser, P. E. Smith, and R. D. Methot. 1992. The daily fecundity reduction method: a new procedure for estimating adult fish biomass. ICES J. mar. Sci. 49:209-215.

Lluch-Belda, D., R. A. Schwartzlose, R. Serra, R. Parrish, T. Kawasaki, D. Hedgecock, and R. J. M. Crawford. 1992. Sardine and anchovy regime fluctuations of abundance in four regions of the world oceans: a workshop report. Fish. Oceanogr. 1(4):339-347.

Regimes of high abundance of sardine, *Sardinops sagax*, and *Sardina pilchardus*, have alternated with regimes of high abundance of anchovy, *Engraulis* spp., in each of the five regions of the world where these taxa co-occur and have been extensively fished. When one taxon has been plentiful, the other has usually been at a reduced level of abundance, and vice versa. Changes in the four heavily fished regions that support *S. sagax*--the Japanese, Californian, Humboldt, and Benguela systems--from a regime dominated by one taxon to a high level of abundance of the other have occurred more-or-less simultaneously. In the Pacific Ocean, sardines have tended to increase during periods of increasing global air and sea temperatures and anchovies have tended to decrease. The Japanese system is dominated by sardines to greater extent than the other systems, and sardines off Japan appear to increase as the Kuroshio Current cools. At the eastern edge of the Pacific Ocean, sardines colonize cooler areas during periods of warming. The Benguela system is out of phase with the three Pacific systems. The four systems all appeared to be in a state of flux in the 1980s. Increased abundance of the subdominant taxon is often one of the first signs of change. Sardines are relatively sedentary in refuge areas when scarce but change behavior to become highly migratory and colonize cooler areas when abundant. Anchovies, by contrast, expand around a fixed geographic center.

Marshall, W. H., and T. W. Echeverria. 1992. Age, length, weight, reproductive cycle and fecundity of the monkeyface prickleback, *Cebidichthys violaceus*. Calif. Fish and Game 78(2):57-64.

Life history characteristics of age, length, weight, reproductive season and fecundity of the monkeyface prickleback, *Cebidichthys violaceus*, were investigated. Most specimens were obtained from poke pole anglers during low tides at Dillon Beach, California. Males and females were aged to 18 years old, with males attaining a larger size. Sexual dimorphic growth occurred after age eight, coincident with maturity in females. A complete length-weight curve was constructed. The age-weight curves for males and females were similar. Females mature as early as four years of age with 100 percent being mature by age eight. Spawning occurs from February through April. Two adult females had an estimated 17,000 and 40,000 mature eggs each.

Mathieu-Costello O., P. J. Agey, R. B. Logemann, R. W. Brill, and P. W. Hochachka. 1992. Capillary-fiber geometrical relationships in tuna red muscle. Can. J. Zool. 70:1218-1229.

Miya, R. K., and G. H. Balazs. 1992. Ecology and conservation of green turtles in the nearshore waters of Waikiki Beach. 'Elepaio 53(2):9-13.

Moffitt, R. B., and F. A. Parrish. 1992. An assessment of the exploitable biomass of *Heterocarpus laevigatus* in the main Hawaiian Islands. Part 2: Observations from a submersible. Fish. Bull., U.S. 90(3):476-482.

Five submersible dives were conducted to evaluate the behavior of deepwater shrimp and the relationship of their density to bottom type and trap yield. Differences in behavior of two species of *Heterocarpus* were observed: *H. ensifer* tended to group around large anemones and other benthic relief over otherwise flat, sandy bottom and were very active in the presence of a baited container; whereas *H. laevigatus* were solitary and showed little activity around a baited container. Greater densities of *H. laevigatus* were observed on volcanic than on coralline substrate, indicating a possible association with this bottom type. Trap catches were regressed against observed *H. laevigatus* densities yielding an estimate of the catchability coefficient. This coefficient differed from that obtained from a previously conducted Leslie model depletion study. Factors contributing to this difference may include comparing estimates of catchability based on data from different areas, bias in the estimate of catchability based on observed density, and bias in the estimate of catchability from the depletion study. A combined fishing and visual census study is suggested as the best assessment technique.

Moser, H. G., and W. Watson. 1992. Distribution and abundance of early life history stages of the California halibut, *Paralichthys californicus*, and comparison with the fantail sole, *Xystreurys liolepis*. Fish. Bull., U.S. 174:31-84.

Moyes, C. D., O. A. Mathieu-Costello, R. W. Brill, and P. W. Hochachka. 1992. Mitochondrial metabolism of cardiac and skeletal muscles from a fast *Katsuwonus pelamis* and a slow *Cyprinus carpio* fish. Can. J. Zool. 70:1246-1253.

Muench, R. D., B. A. Huber, J. T. Gunn, D. M. Husby, and D. G. Mountain. 1992. The Weddell-Scotia marginal ice zone: physical oceanographic conditions, geographical and seasonal variability. J. Mar. Systems 2:169-182.

Niethammer, K. R., G. H. Balazs, G. L. Nakai, and D. K. McDermond. 1992. Great frigatebird, *Fregata minor*, predation: not a factor in hatching green turtle, *Chelonia mydas*, survival at French Frigate Shoals, Hawaii. Colonial Waterbirds 15(1):128-131.

Pearson, D. E., S. L. Owen. 1992. English sole. *In* W. S. Leet, C. M. Dewees, and C. W. Haugen (eds.). California's Living Marine Resources and Their Utilization, pp. 99-100. California Sea Grant Extension Publication UCSGEP-92-12.

Pitman, R. L., and L. T. Ballance. 1992. Parkinson's petrel distribution and foraging ecology in the eastern pacific: aspects of and exclusive feeding relationship with dolphins. The Condor 94:825-835.

During 28 research vessel cruises in the eastern tropical Pacific Ocean from 1976 through 1990, Parkinson's petrels, *Procellaria parkinsoni*, were observed near shore from southern Mexico (about 15° N) to northern Peru (about 5° S), and along a broad seaward extension

that continued west of the Galápagos Islands to 110° W. Parkinson's petrels regularly associated with dolphins: of the 618 petrels observed, 469 (76%) were associated with 10 species of dolphins, on 55 occasions, with 1 to 300 petrels present. They occurred mostly with two rare dolphin species: the melon-headed whale, *Peponocephala electra*, and the false killer whale, *Pseudorca crassidens*. This appeared to be a largely obligatory foraging relationship for Parkinson's petrels. Associations with other dolphin species occurred primarily when those species also associated with melon-headed and false killer whales. Parkinson's petrels avoided a common and widespread, multispecies feeding assemblage which consisted of a diverse, fast-moving group of seabirds, spotted and spinner dolphins, *Stenella attenuata* and *S. longirostris*, and tuna, all of which feed on live prey forced to the surface. The lumbering Parkinson's petrels appeared ill-equipped to take such prey. In contrast, melon-headed and false killer whales apparently fed by dismembering large prey below the surface and so, provided feeding opportunities for a scavenging bird with diving capabilities. Among eastern tropical Pacific (ETP) seabirds, Parkinson's petrels alone are adapted for recovering food scraps well below the surface. Parkinson's petrels appear to be more dependent on marine mammals for foraging than any other species of seabird studied and feed diurnally more than was previously thought.

Polovina, J. J., and G. T. Mitchum. 1992. Variability in spiny lobster, *Panulirus marginatus*, recruitment and sea level in the Northwestern Hawaiian Islands. (Contribution 2820 of the School of Ocean and Earth Science and Technology, University of Hawaii; JIMAR Contribution 91-0243). Fish. Bull., U.S. 90(3):483-493.

Research and commercial trapping data show variation in recruitment to the fishery for spiny lobster, *Panulirus marginatus*, at Maro Reef, relative to Necker Island which is 670 km to the southeast. Recruitment to the fishery at Maro Reef is shown to be highly correlated with the difference in sea level 4 years earlier between French Frigate Shoals and Midway Islands. Geosat altimeter data indicate that the relative sea level between French Frigate Shoals and Midway is an indicator of the strength of the Subtropical Counter Current. Mechanisms linking the Subtropical Counter Current with larval advection and survival are discussed. The sea level index provides a forecast of recruitment 4 years later to the fishery at Maro Reef.

Rago, T. A, P. F. Jessen, L. K. Rosenfeld, S. R. Ramp, C. A. Collins, N. Garfield, and F. B. Schwing. 1992. Hydrographic and acoustic doppler current profiler (ADCP) data from the Farallones shelf and slope study, May 16-21, 1991, Naval Postgraduate School Technical Report NPS-OC-92-006. 184 p.

Ralston, S., and D. T. Tagami. 1992. An assessment of the exploitable biomass of *Heterocarpus laevigatus* in the main Hawaiian Islands. Part I: Trapping surveys, depletion experiment, and length structure. Fish. Bull., U.S. 90(3):494-504.

A deepwater trapping survey for *Heterocarpus laevigatus* was conducted around the main islands of the Hawaiian Archipelago to estimate exploitable biomass and potential yield. Stratified sampling by depth zone and island was conducted over a 3-year period to evaluate shrimp catch rates. Catchability of the traps was estimated from a 12-day intensive fishing experiment performed at a small, isolated site in the Kaulakahi Channel; habitat areas were determined by digitizing nautical charts.

Results from a Leslie analysis of the depletion experiment showed that *H. laevigatus* is very susceptible to capture by traps (i.e., catchability $\hat{q}$ = 9.48 ha/trap-night). There was no evidence of a change in size structure through the course of the experiment.

Shrimp catch rates varied greatly by island and depth of capture. Exploitable biomass was greatest in the 460-640 m depth range; negligible amounts of shrimp occurred shallower than 350 m and deeper than 830 m. Catch rates were highest at Niihau and lowest at Oahu. The total exploitable biomass of shrimp in the main Hawaiian Islands was estimated to be 271 t, a figure substantially less than previously believed.

Analysis of multiple size-frequency distributions for each sex showed no evidence of modal size progression. Assuming equilibrium conditions, application of the Wetherall et al. (1987) method to these data resulted in estimates of M/K = 1.01 for female shrimp and 0.74 for males. From these results and estimates of L_∞ the scientists calculate that $F_{0.1}/M$=0.75 for females and 0.86 for males.

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The diets of pelagic juveniles of widow rockfish, *Sebastes entomelas*; yellowtail rockfish, *S. flavidus*; Chilipepper, *S. goodei*; shortbelly rockfish, *S. jordani*; and bocaccio, *S. paucispinis*, were compared using samples collected during 1984-87. All five species co-occur as pelagic juveniles off central California. Frequency of occurrence, percent of number, and ranking index of prey items were determined from 1088 stomachs. Major prey of pelagic juvenile rockfish were the various life stages of calanoid copepods and subadult euphausiids (including eggs).

For each year, dietary overlap was quantified between interspecific pairs using the Colwell and Futuyma

(1971) index. Amount of overlap varied from year to year. Long-term intraspecific dietary overlap, based on the 4 years of data, was generally less than interspecific overlap within years. Year-to-year variation in the diets of these species was generally greater than within-year variation among them, suggesting that, as a group, pelagic juvenile rockfishes are opportunistic feeders. Also, if interannual variation in the distribution and abundance of foods has a major impact on recruitment, the high dietary overlaps of these co-occurring species would suggest parallel survival and year-class success.

Multivariate analysis of variance was used to examine the effects of latitude, depth, and fish size on food consumption. Alterations in diet were related to latitude, depth, and a latitude-depth interaction for three species in 1987 and, also, for shortbelly rockfish in 1984-86. Diet was apparently unrelated to fish size.

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Surveys in the southern California Bight have shown rapid increases in the spawning rate of Pacific sardine over the past decade. The scientists found simple deterministic population models to be useful for examining the rates of change observed in the sardine population. The scientists first describe the "best guess" parameters of an equilibrium sardine population with the Leslie matrix model. From this they determine that small changes in annual mortality rate of the O-group impose high rates of change in the population. The scientists then erect a Lefkovitch matrix model, which uses life stages rather than ages, to emphasize the parameters of the early life stages. From this study, the scientists can specify the range of growth rates and the changes in survival rates for each developmental stage, as well as the adult parameters required to evaluate the observed rates of change.

Changes in egg production rates imply important changes in the sardine population. Therefore, exchanges of these rates of change can offer insight into the frequency and precision of population assessment and recruitment prediction required for effective management of fisheries on sardines and other stocks.

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Ueber, E., and A. D. MacCall. 1992. The rise and fall of the California sardine empire. *In* Glantz, Michael (ed.), Climate Variability, Climate Change and Fisheries, pp. 31-48. Cambridge University Press, Cambridge, England.

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Spatial and temporal distributions of larval Pacific sardine, *Sardinops sagax*, were investigated at two nearshore sites between San Onofre and Oceanside, California. Neuston, midwater, and epibenthic samples were collected at night with plankton nets towed at a randomly selected isobath within each of five sampling blocks between the 6-m and 75-m isobaths at each site. The San Onofre site was sampled from January 1978 through September 1986; the site near Oceanside was sampled from July 1979 through September 1986. Sampling frequency varied from weekly

to quarterly, depending on other requirements of the study.

The average cross-shelf distribution of larvae differed little from year to year: abundance usually was highest between the 12-m and 45-m isobaths, particularly for yolk-sac and preflexion larvae. Densities were typically highest in midwater. Vertical and cross-shelf distributions were similar at both study sites.

Larvae were found nearly year-round, but were most abundant in summer and fall. Seasonal abundance patterns differed relatively little between sites or from year to year. Abundance was quite low from 1978 to 1980, then increased dramatically to a peak in 1984.

The results of this study, together with other published reports, suggest that the resurgence of the Pacific sardine off southern California in the early 1980s began in 1981 in shallow waters along the central southern California coast.

Watson, C. L., H. A. Morrow, and R. W. Brill. 1992. Proteolysis of skeletal muscle in yellowfin tuna, *Thunnus albacores*: evidence of calpain activation. Comp. Biochem. Physiol. 103B(4):881-887.

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Approved by Science and Research Director, SWR

This **Approved by Science and Research Director** list is for those publications approved by the Science and Research Director in November and December, 1992, for all Laboratories.

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